

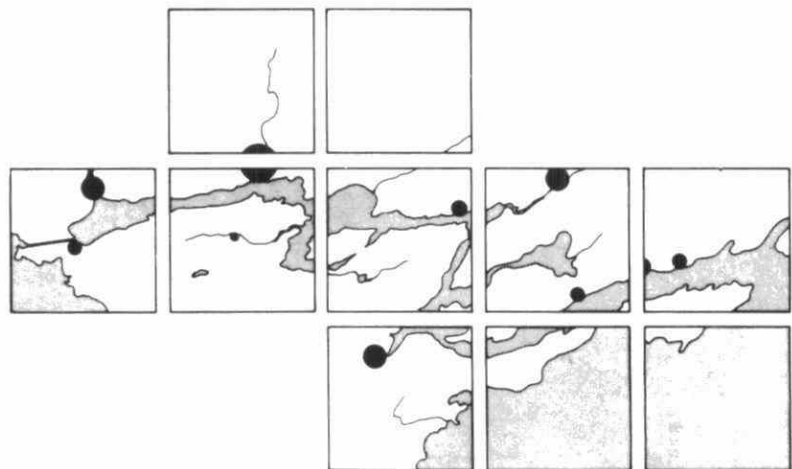


Bay of Quinte Remedial Action Plan

Stage 1

Environmental Setting + Problem Definition

Remedial Action Plan Coordinating Committee



July 1990

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BAY OF QUINTE REMEDIAL ACTION PLAN
STAGE 1 REPORT
ENVIRONMENTAL SETTING + PROBLEM DEFINITION

ENVIRONMENT ONTARIO
ENVIRONMENT CANADA
FISHERIES AND OCEANS CANADA
ONTARIO MINISTRY OF NATURAL RESOURCES
ONTARIO MINISTRY OF AGRICULTURE AND FOOD

July 1990

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EXECUTIVE SUMMARY

BAY OF QUINTE ECOSYSTEM - OVERVIEW AND STATUS

In 1975, the Bay of Quinte was identified as a "Problem Area" to the International Joint Commission (IJC) owing, in part, to excessive nutrient enrichment, nuisance algal growths, low concentrations of dissolved oxygen in bottom waters, and localized bacterial concerns. Subsequently, a number of abatement activities were undertaken and water quality conditions generally improved. In 1985, the Water Quality Board of the IJC once again identified the Bay of Quinte as an "Area of Concern" (AOC), as defined by the Canada-United States Great Lakes Water Quality Agreement. Water quality had deteriorated again, and the derived beneficial uses of the water were impaired by the above factors and toxic contamination. The concerns are summarized below.

1. General Physical Conditions

- . The Bay of Quinte is part of the northeastern shore of Lake Ontario. The bay is about 100 km in length and 254 km² in area, and is largely separated from Lake Ontario by Prince Edward County and Amherst Island.
- . Three morphologically different smaller bays make up the Bay of Quinte: the upper, middle and lower bays (Figure 1). The upper bay extends from Trenton eastward past Belleville and Deseronto to the end of Long Reach. Four major rivers flow into the upper bay: the Trent, Moira, Salmon and Napanee. The Town of Napanee is located on the Napanee River, while the Cities of Trenton and Belleville, Canadian Forces Base Trenton (CFB Trenton), and the Town of Deseronto are located along the north shore of the upper bay.
- . The middle bay consists of the area between Long Reach and Glenora including Hay Bay. The Town of Picton is located near the Glenora Narrows.

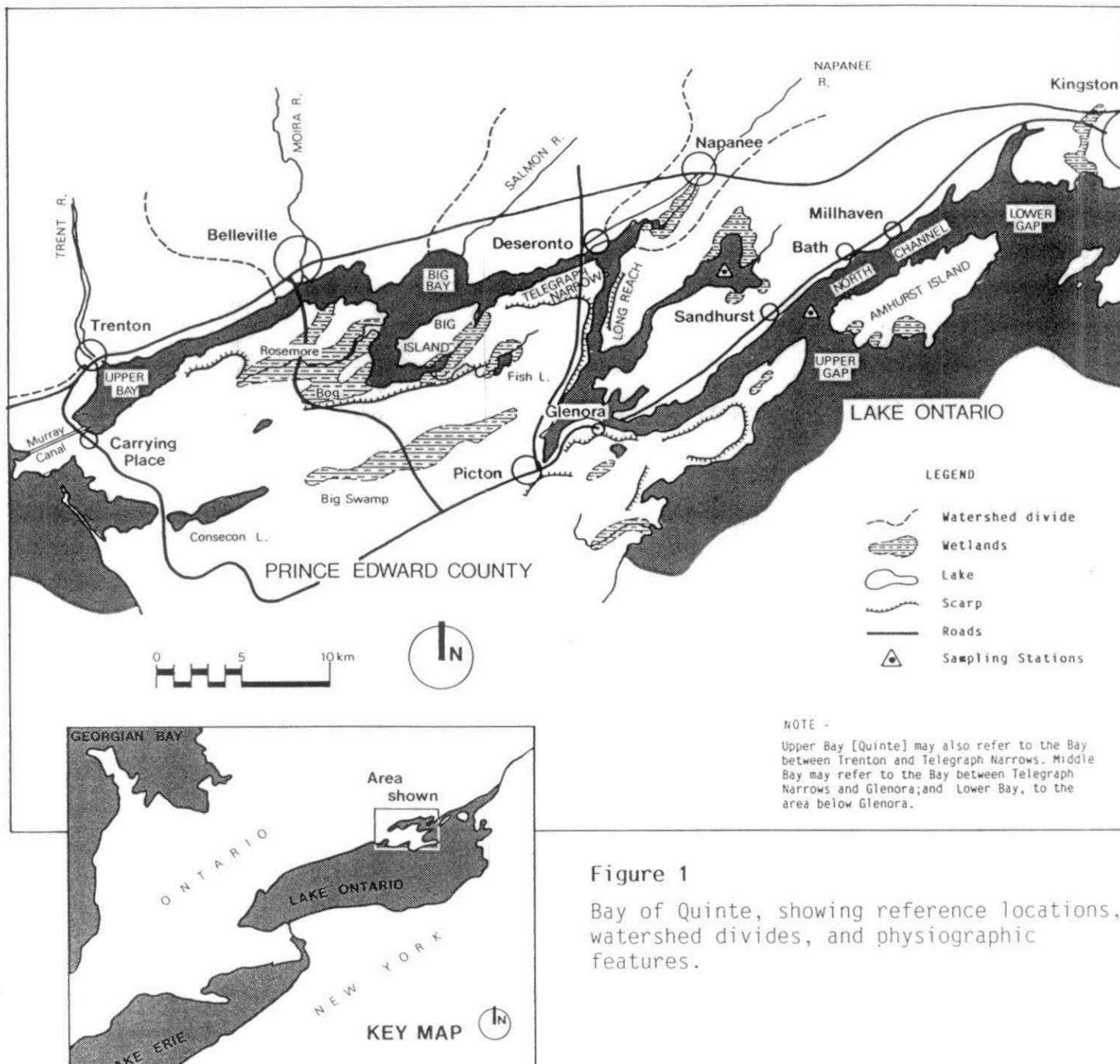


Figure 1

Bay of Quinte, showing reference locations, watershed divides, and physiographic features.

- . The lower bay extends southeast of Glenora, past Conway and the Ontario Hydro Lennox Generating Station, and past the Upper Gap to a point halfway along Amherst Island.
- . Incursions of Lake Ontario water into the lower and middle bays influence water quality in these systems. Lake Ontario water does not enter the upper bay; rather, precipitation and tributary flows impact on dilution capacity, flushing rates and water quality.

2. Pollution Problems

- (a) Phosphorus Loadings from Human Activities Have Impacted Adversely on Water Quality and the Bay of Quinte's Ecosystem.

- . The process of cultural eutrophication commenced in the late 1700s with the arrival of the United Empire Loyalists and their clearing of the watershed for homesteading. By the end of the 1800s, most of the bay's 1,750,000 hectare watershed had been deforested, and about one third of the land had been placed into agricultural production.

The earliest indication of a diffuse source nutrient enrichment problem appeared in the December 17, 1904 issue of the Daily Ontarian, which made reference to an algal slime in the upper bay. In 1938, commercial fishermen encountered for the first time, severe fouling of their nets with filamentous algae. By this time, municipal water treatment plants were plagued with algal related taste and odour problems. During the 1940s, the bay's highly lucrative lake herring commercial fishery collapsed. Fouling of spawning beds with filamentous algae is the suspected cause.

- . A further indication of a nutrient enrichment problem became evident during the 1940s and 1950s with a shift in the fish community structure from northern pike and largemouth bass and smallmouth bass to one dominated by walleye. While this shift was a welcome one in

some respects, it signified a shift in community composition from sight feeders to one of non-sight feeding fish species - an indication of more turbid water caused by increased algal stocks.

- . Between 1950 and 1975, the densities of algae and zooplankton were among the highest ever recorded for natural Canadian freshwater systems. These "productive" conditions at the primary levels of the food chain generated, directly and indirectly, noticeable changes at the secondary and tertiary levels (i.e., the aquatic plant and animal communities). For example, Eurasian milfoil, an aquatic plant, invaded the bay, and along with the shading effects of the massive algal growths, crowded out the native plants. As well, climatic conditions allowed a successful invasion of white perch, at the expense of walleye, lake whitefish and gar, and the remnant northern pike and largemouth bass and smallmouth bass populations.
- . However, during the 1970s, some encouraging signs of ecosystem recovery materialized.
 1. Point source nutrient control measures substantially reduced phosphorus loadings to the bay.
 2. The biomass of pollution tolerant bottom faunal species (i.e., oligochaetes, sphaerids and isopods) declined.
 3. Walleye returned in substantial numbers in 1978, and a corresponding decline in white perch biomass occurred.
- . Despite these improvements, the ecosystem did not respond in other important ways. For example, while municipal phosphorus loadings from the water pollution control plants were reduced by about 50%, total phosphorus concentration and algal abundance in the upper bay declined by only 35%. The nitrogen to phosphorus ratio, which influences algal composition, increased from a low of 10:1 in 1978

to 22:1 in 1987, which is not high enough to have a meaningful effect on algal structure. Accordingly, the community is still dominated by those species present before phosphorus loading reductions: Stephanodiscus and Melosira in the spring and summer respectively; and Aphanizomenon and Anabaena (nitrogen fixing blue-green algae) in the late summer. Likewise, small bodied cladocerans which are normally found in enriched waters, are still the most common zooplanktonic species. Although recent evidence suggests that submerged aquatic plants are recovering, the diversity, community structure and biomass have remained low, due to the shading effects of algae and poor sediment quality. Lastly, the fish community, altered in part by earlier pollutional stresses, has not recovered or stabilized. Alewife and walleye continue to dominate, though smallmouth bass and lake whitefish are increasing in biomass.

- . In recent years, algal abundance has remained high even though total phosphorus concentrations have been among the lowest on record. For example, the 1987 average ice-free phosphorus concentration was quite low (i.e., 37 ug/L) in the upper bay, yet algal biomass was high, as indicated by an average chlorophyll a of 25.4 ug/L. Recent evidence suggests that man-made phosphorus loads, coupled with phosphorus feedback from the sediments and a strong, top-down food chain-ecosystem influence (i.e., white perch and alewife keep the algal grazers [i.e., zooplankton] cropped) allow algal biomass to fluctuate. Thus, the problem is a two-fold one: first, phosphorus concentrations are still too high, accounting for the high production rate of algae; and second, the top-down influence does not permit a total ecosystem recovery.
- . Key to the Bay of Quinte's recovery is a return of macrophytes. They will assist in reducing the feedback of phosphorus from the sediments, and provide habitat for the algal grazers and white perch predators (i.e., northern pike).

(b) Bacterial Densities Have Exceeded Water Quality Objectives for Swimming and Bathing.

- . Beaches and swimming areas are closed periodically because of high bacterial counts. The areas adversely impacted include: the lower reaches of the Trent River and extending outward into the bay; in the Moira River and along the Belleville waterfront; on the north shore of the Napanee River; and in Picton Bay to within a few hundred metres of Picton Marsh Creek. Bypassing at municipal water pollution control plants, poor livestock management, urban stormwater runoff, pleasure boats, industrial sources, combined sewer overflows, inflow and infiltration, and illegal connections contribute to the problem.

(c) Heavy Metals and Toxic Contaminants Have Been Found in the Waters, Sediments and the Fish of the Bay of Quinte in Excess of Guidelines.

- . While heavy metals in surface waters have been reduced in recent years, ambient water quality objectives were exceeded in 1988 for copper (7% of the samples analyzed), cadmium (6% of the samples analyzed) and iron (2% of the samples analyzed).
- . Phenol and pentachlorophenol (PCP) are the most frequently reported toxic organic contaminants in excess of Ministry of the Environment's (MOE) ambient water quality objectives for the protection of aquatic life.
- . Sediments in areas around Trenton, Belleville and Picton contain one or more of arsenic, cadmium, chromium, copper, iron, mercury, nickel, lead or zinc in excess of provincial guidelines for open water disposal of dredged sediments.
- . As well, polychlorinated biphenyl (PCB) concentrations have been found in excess of provincial guidelines for open water disposal of

dredged spoils in sediment samples taken at the mouths of the Trent and Moira rivers.

- . The above heavy metal and toxic contaminants are found as constituents in sewage treatment plant effluents and industrial discharges, and in the municipal sewer collection systems. In 1988, 22 trace organic compounds were detected in sewage treatment plant and industrial effluents released to tributaries and municipal sewers; PCP and benzene hexachloride (BHC) were the most frequently detected compounds.
- . Three paper mills (Domtar Packaging - Trenton, Trent Valley Paperboard - Glen Miller, and Strathcona Paper - Strathcona), one wood preserving operation (Domtar Wood Preserving - Trenton), one chemical plant (Bakelite Thermosets Limited - Belleville), and one distillery (Corby Distilleries - Corbyville) are located within 10 km of the Bay of Quinte; these discharge treated effluent either directly to the bay or to Bay of Quinte tributaries.
- . Domtar Packaging, Trent Valley Paperboard and Strathcona Paper Company: At Domtar Packaging, Canadian Pulp and Paper Effluent Regulations for discharge of suspended solids was exceeded recently in 4 of 12 samples (33%). Likewise, the MOE's Certificate of Approval objective for suspended solids was exceeded in 12 of 12 samples (100%) at Trent Valley Paperboard (Ontario Ministry of the Environment 1989). In 1988, the Strathcona Paper Company was always in compliance with its monthly discharge limits for BOD₅ and suspended solids (Ontario Ministry of the Environment 1989). Sampling of heavy metals, chlorinated hydrocarbons and toxic organics in effluent waste streams as stipulated by Ontario's Municipal/Industrial Strategy for Abatement (MISA) regulations commenced January, 1990.
- . Domtar Wood Preserving: In 1988, the Certificate of Approval

standards for phenol (0.02 mg/L) and PCP (0.5 mg/L) in effluent discharges were exceeded in 7 of 20 (35%) and 10 of 12 (83%) samples respectively (Ontario Ministry of the Environment 1989). All production operations ceased January, 1990. To limit "storm related runoff-waste discharges", pollution abatement facilities/operations are being maintained by a single staff member.

- . Bakelite Thermosets Limited: In 1988, phenol levels in effluent discharges exceeded Ontario's objective for the control of industrial waste discharges of 0.02 mg/L in 9 of 24 samples (37.5%) (Ontario Ministry of the Environment 1989). In 1989, the plant was sold; the property is still owned by Bakelite Thermosets Limited. Decommissioning plans for the site are unknown at this time.
- . Corby Distilleries: The Moira River below the Corby Distilleries outfall was characterized by fecal coliform counts as high as 5.8×10^5 organisms/100 mL during surveys undertaken in 1985. Agricultural drainage north and east of the plant is the probable source of contamination, as the distillery operates during winter months only (Ontario Ministry of the Environment 1986).
- . Although mining is no longer a significant activity within the watershed, sediments at the mouths of inflowing tributaries are enriched with metals from past upstream operations.
- . Most fish species sampled from the Bay of Quinte have concentrations of contaminants in flesh which are below consumption advisory levels. Notable exceptions, based on PCB and Mirex in excess of provincial and federal consumption guidelines, apply to larger size classes of certain species including: walleye and channel catfish of 45 cm (i.e., 18 inches) in length or larger; smallmouth and largemouth bass of 35 cm (i.e., 14 inches) or larger; northern pike

of 65 cm (i.e., 26 inches) or larger; and American eel of 65 cm or more. In fact, walleye greater than 65 cm in length and channel catfish greater than 55 cm should not be consumed at all.

- . Dioxins and furans have also been detected in large size classes of walleye, though the concentrations do not exceed Health and Welfare Canada guidelines for consumption. The average total concentration expressed as 2,3,7,8-TCDD equivalents in edible portions of flesh from five large walleye sampled in 1989 from Big Bay by MOE was 5.1 ng/g; the consumption guideline is 20 ng/g in edible portions.
 - . The movement of fish between Lake Ontario and the Bay of Quinte, and atmospheric deposition are additional sources of toxics to the bay ecosystem. The magnitude of these inputs and their implications are presently unknown.
 - . Treated municipal and institutional wastes are discharged to the bay from secondary sewage treatment plants at: Trenton, CFB Trenton, Belleville, Deseronto, Napanee, Picton and Prince Edward Heights.
- (d) Losses of Emergent and Submergent Aquatic Plants and Shoreline Wetlands Have Adversely Impacted Water Quality.
- . About two-thirds (12,000 ha) of the Bay of Quinte shoreline wetlands have been converted to agricultural, urban or residential uses. These losses mean that: significant destruction of the littoral zone has occurred; fish and wildlife habitats have been destroyed; sediments are more readily resuspended by physical wind and wave actions; land retention time for nutrients and contaminants has been reduced; and indirectly, algal stocks remain at unacceptably high levels.
 - . Approximately 6,700 ha of wetlands distributed throughout the bay remain. The largest complexes occur at Muscote Bay, Hungry Bay and

Hay Bay. Demand for shoreline development threatens these sites and similar smaller wetland areas around the bay and within its watershed.

(e) Other Factors Affecting the Bay of Quinte's Aquatic Ecosystem Are Predator-Prey Interactions.

- . Colder than normal temperatures and unusual ice formations in 1977-78 have contributed, in part, to a decline in white perch to such an extent that predation by walleye now controls the production and biomass of white perch.
- . The recovery of Pontoporeia hoyi in the lower bay after 1977 is believed to be related to the collapse of white perch.
- . Fish grazing on zooplanktonic Daphnia influence the extent to which zooplankton predate on algae; accordingly, the degree of fish grazing indirectly controls algal abundances.

In summary, the Bay of Quinte has five environmental concerns: nutrient enrichment resulting in, among other things, nuisance algal growths; bacteriological contamination; some forms of toxic and heavy metal contamination; shoreline-wetland destruction; and an unstable ecosystem.

Table A summarizes the fourteen beneficial uses outlined in Annex 2 of the Revised Great Lakes Water Quality Agreement of 1978 (1987), and their significance to the Bay of Quinte. This table was compiled by the Bay of Quinte RAP Coordinating Committee with the assistance of PAC.

Table B is a revised list of environmental concerns confirmed at two ecosystem modelling workshops. It summarizes the Bay of Quinte's current conditions, impaired beneficial uses, and problem sources and information deficiencies.

Table A. Summary of impairment of potential beneficial uses as outlined in Annex 2 of the Great Lakes Water Quality Agreement (1987) and their significance to the Bay of Quinte.

POTENTIAL IMPAIRED USE	SIGNIFICANCE TO BAY OF QUINTE
1. Restrictions on fish and wildlife consumption	Fish consumption of some large size classes of certain species of fish is restricted. For example, Mirex and PCB levels in walleye and channel catfish greater than 45 cm in length, smallmouth and largemouth bass greater than 35 cm in length, northern pike and American eel greater than 65 cm in length exceed human consumption guidelines. Walleye greater than 65 cm in length and channel catfish greater than 55 cm in length should not be consumed at all. Wildlife consumption is not restricted Pollution sources beyond and within the boundaries of the Area of Concern must be located and delineated.
2. Tainting of fish and wildlife flavour	Tainting has not been identified as an impaired beneficial use in the Bay of Quinte.
3. Degradation of fish and wildlife populations	The fish communities in the bay are self-reproducing and typical of eutrophic systems; however, they are not diverse. A collapse of one or more species could translate into lost angling opportunities and a further unbalanced ecosystem. There is no documented, observational or anecdotal evidence of wildlife population degradation.
4. Fish tumors or other deformities	On the basis of professional observations and public anecdotal reports, tumors or other deformities have not been identified as an impaired beneficial use in the Bay of Quinte.

5. Bird or animal deformities or reproduction problems	There is no site specific documented, observational or anecdotal evidence of bird or animal deformities and/or reproductive problems resulting from toxic contamination. High levels of chlorinated hydrocarbons have adversely affected reproductive success in eastern Lake Ontario populations of double-crested cormorants and herring gulls; but, these occurrences are not isolated to the Area of Concern. This potentially impaired beneficial use needs to be assessed in the Bay of Quinte.
6. Degradation of benthos	Based on scientific evidence, the Bay of Quinte benthic communities are degraded. In recent years, some improvements have been observed and species composition has shifted away from the more pollution tolerant oligochaetes, although the community still remains altered relative to 1939 conditions. Ecological understanding is limited.
7. Eutrophication or undesirable algae	The average phosphorus concentration in the upper bay between 1978 and 1988 was 49 ug/L, representing a substantial reduction from 78 ug/L for the 1972 to 1977 period. The bay is still eutrophic and highly productive, and nuisance algal blooms have been reported. Algal growth has limited submergent macrophyte growth and may impair swimming, boating, aesthetics and ecosystem diversification.
8. Restrictions on drinking water consumption, or taste and odour problems	Taste and odour problems have been reported. The problem is caused by excessive algal growths, and is compounded by the the degree of chemical treatment undertaken at the local water treatment plants. Restrictions against using Bay of Quinte water as a raw water supply have not been imposed, although alternative drinking water supplies have been sought by some municipalities.

9. Restrictions on dredging activities	Dredging of bay sediments is restricted because some heavy metal levels exceed dredge spoil disposal guidelines for open waters. Current conditions are being evaluated, and the extent of the problem has to be delineated further. The levels of toxic organics and other contaminants in the sediments is currently being assessed.
10. Beach closings	Beaches throughout the Bay of Quinte periodically are closed because fecal coliform counts exceed 100 in 100 mL of water (the body contact recreation guideline). Recreational opportunities are lost, health risks are increased and tourism revenue is forfeited. Some sources have been identified (e.g., combined sewers, poor livestock practices, inflow and infiltration), and some general corrective actions have been recommended, but more work is needed to define the relative contribution of each source and the exact corrective work.
11. Degradation of aesthetics	Degraded aesthetics have been reported (eg., algal blooms). Current conditions need to be improved, and the problem is under assessment.
12. Added costs to agriculture or industry	Added cost to pre-treat water has not been identified as an impaired beneficial use in the Bay of Quinte.
13. Degradation of phytoplankton and zooplankton populations	Community composition is typical of eutrophic waters. The phytoplankton community is dominated by the diatoms <u>Melosira</u> and <u>Stephanodiscus</u>, and nitrogen fixing blue-green algae. No evidence of any toxic effects on algae or zooplankton has been recorded. Desired zooplankton species are suppressed by food chain impacts (i.e., predation by perch and alewife), and ecosystem management controls need to be assessed.

14. Loss of fish and
wildlife habitat

Loss of fish and wildlife habitat has been identified as an impaired beneficial use. An estimated 12,000 ha of wetland has been converted to other uses. Historical modification of shoreline can be attributed to the degree of eutrophication, and man's activities including growth pressures, lack of adequate legislation, no available management policies, no concept or process of ecosystem management, and/or changes in long term Great Lakes water levels.

Table B: Summary of environmental problems affecting the Bay of Quinte.

Environmental problem	Current conditions	Impaired uses	Source of problems	Information deficiencies
Eutrophication	.phosphorus and algal densities are still high and fluctuate widely .poor water clarity .nitrogen/phosphorus ratios not yet high enough to change species composition of algae to less troublesome species .low dissolved oxygen in deep waters .fish community approaching a typical eutrophic system with some indications of early mesotrophy .loss of fish and wildlife habitat .sediments now acting as a source of phosphorus to overlying surface waters .Food chain interactions exerting an influence on trophic conditions	.degraded water quality for drinking and swimming .diminished aesthetics .reduced opportunities for fishing, hunting trapping and nature appreciation	.diffuse sources including agricultural activities and inland sewage treatment plants .sewage treatment plants which discharge directly to the bay .atmospheric phosphorus .sediment phosphorus reflux .phosphorus in water treatment plant waste water .phosphorus in industrial discharges .phosphorus in urban runoff	.broad confidence limits around amount of phosphorus generated from sediments .no knowledge on length of time before sediments act as sink rather than source for phosphorus .confirmation and quantification that predator-prey interactions at secondary and tertiary levels are influencing ecosystem processes .extent, quality and management of fish habitat and fish community structure needed to balance Bay of Quinte ecosystem

Table B (cont'd)

Heavy metals in water	.copper, cadmium and iron occasionally exceed Provincial Water Quality Objectives in ambient water, and for the protection of aquatic life. .no exceedences of Ontario Drinking Water Objectives in water supplies	.possible impacts on aquatic life	.past and present industrial activities .Domtar Packaging .Domtar Wood Preserving .Trent Valley Paperboard Mills .Trenton sewage treatment plant .possible inputs from landfills, either inland or located on shoreline .possible inputs from sediments	.fate and transport of contaminants presently being modelled .relative contribution and significance of each source needs to be developed to identify remedial options
Heavy metals in sediments	.arsenic, cadmium, chromium, copper, iron, mercury, nickel, lead and/or zinc exceedences of provincial dredge spoil disposal guidelines in sediments in the Trenton, Belleville, Deseronto and Picton areas.	.as above	.as above	.evaluation of current conditions could change depending on evaluation and interpretation of 1988 data

Table B (cont'd)

Toxic organics in water	.phenol and PCP levels occasionally exceed Provincial Water Quality Objectives in ambient water .Provincial Objectives for Control of Industrial Waste Discharges have been exceeded at Bakelite Thermosets .Provincial Certificate of Approval limits for phenol and PCP in effluent discharges have been exceeded at Domtar Wood Pre- serving - Trenton .no exceedences of Ontario Drinking Water Objectives in water supplies	.as above	.Trent Valley Paperboard Mills .Domtar Wood Preserving .Domtar Packaging .Bakelite Thermosets .Strathcona Papers .all sewage treatment plants with highest levels at Trenton .possible inputs from landfills, either inland or located on shoreline .agricultural runoff	.fate and transport of contaminants presently being modelled .relative significance of each source needs to be clarified
Toxic organics in sediments	.PCB exceedences of provincial dredge spoil disposal guidelines at mouth of Trent and Moira rivers	.as above	.no confirmed active local sources	.evaluation of current conditions could change depending on analyses and interpretation of 1988 data

Table B (cont'd)

Heavy metals and toxic organics in fish	.elevated levels of Mirex and PCBs in large size classes of walleye, American eel, channel catfish, smallmouth and largemouth bass and northern pike.	.restrictions on fish consumption	.no confirmed sources .contaminant transport by fish from Lake Ontario into Bay of Quinte is a probable factor	.need to confirm whether contaminant levels result from water or sediments within the bay or are derived from external sources
Loss of fish and wildlife habitat	.two-thirds of the Bay of Quinte's original wetlands have been lost .about 6,700 ha remain, including 2,500 ha of swamp and 3,800 ha of emergent community types .shoreline under extreme development pressures	.loss of fishing and hunting opportunities .lack of stability of plant and animal community .aesthetics	.conversion to agricultural and residential uses .beds of Eurasian milfoil have not completely declined .near shore losses of sediments in hypereutrophic years	.poor understanding of submerged plant communities and their failure to respond as anticipated to phosphorus control measures .information on wetlands and shorelines to be digitized in mapping format

Table B (cont'd)

Bacteriological contamination	.water quality objectives exceeded in the lower reaches of the Trent River and extending outward into the bay, in the Moira River and along the Belleville waterfront, at the mouth of the Napanee River, and in Picton Bay	.restrictions/beach closures for swimming, bathing and wading	.only partial separation of sanitary/stormwater systems at Belleville, Canadian Forces Base Trenton and Napanee .by-passing at Belleville, Prince Edward Heights and CFB Trenton .inflow/infiltration at Belleville, Trenton, Canadian Forces Base Trenton, Picton, and Prince Edward Heights .illegal cross connections between domestic sewage and storm sewer systems at Trenton and Belleville .unresolved source of fecal coliform associated with the Domtar Packaging discharge .urban runoff .runoff from livestock wastes and manure spreading .potential illegal discharges from pleasure boats .landfill sites	.no estimates of loadings from sources to prioritize remedial actions
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Table B (cont'd)

Unbalanced and unstable plant and animal communities	.present fish community is close to resembling the eutrophic structure of the late 1950s and early 1960s .recent appearance of lake whitefish is first indication of more diverse fish community, similar to that of the 1940s and early 1950s. .current walleye fishery is excellent .diversity of sports fishery remains low owing to low number of northern pike and bass	.walleye fishery could suddenly decline from natural causes, leading to lost angling opportunities	.plant and animal communities particularly sensitive to natural and/or artificial changes .incremental losses of fish and wildlife habitat .inability of resource managers to protect ecosystem components	.better data on how many fish can be safely harvested without depleting overall stocks .insufficient information on desirable fish species mix .poor data on effectiveness of management tactics to control fish community structure.
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3. Bay of Quinte Remedial Action Plan Development Process

The Bay of Quinte RAP is being developed as a joint effort by a ten member Federal/Provincial Coordinating Committee and a twenty-one member Public Advisory Committee (PAC). Aided by Project Quinte, the Bay of Quinte RAP team has filled key data gaps and evaluated some of potential remedial options. The most important scientific/technical activities and milestones are listed below. The products - Bay of Quinte Remedial Action Plan technical reports - are attached as Appendices to this document.

Technical workshop with RAP team, Project Quinte scientists and key resource managers	September, 1986
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<u>Progress Report on Status of the Bay of Quinte</u>	February, 1987
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<u>Technical Report No. 1 - An Evaluation of Persistent Toxic Contaminants in Bay of Quinte Ecosystem</u>	January, 1988
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<u>Technical Report No. 2 - An Evaluation of Point Source Discharges to the Bay of Quinte Ecosystem</u>	March, 1988
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<u>Technical Report No. 3 - The Feasibility of Increasing the Hydrologic Flushing Rate of the Upper Bay of Quinte</u>	November, 1987
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<u>Technical Report No. 4 - Analyses of Agricultural Diffuse Source Loadings to the Bay of Quinte</u>	September, 1988
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First ecosystem modelling workshop	April, 1988
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Second ecosystem modelling workshop	June, 1988
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<u>Technical Report No. 5 - 1987 Bacteriological Water Quality at Trenton, Deseronto and Picton - Bay of Quinte</u>	January, 1989
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<u>Technical Report No. 6 - Bay of Quinte Ecosystem Based Analyses of Remedial Options</u>	November, 1989
<u>Technical Report No. 7 - Feasibility of Decreasing Bay of Quinte Sediment Nutrient Flux</u>	June, 1989
<u>Time to Decide - A Discussion Paper</u>	September, 1989
<u>Technical Report No. 8 - Evaluation of Landfill Sites as Potential Sources of Toxic Inputs to Bay of Quinte</u>	December, 1989
<u>Technical Report No. 9 - Distribution, Species Composition and Biomass of Macrophytes in the Bay of Quinte - A Comparison of Methodologies</u>	December, 1989
<u>Technical Report No. 10 (to be issued)</u>	Spring, 1990
<u>Bay of Quinte Stage 1 Report - Environmental Setting + Problem Definition</u>	March, 1990
Toxics Fate and Transport Study and Model Development	Spring, 1990
Wetlands and Littoral Zone Inventory, Mapping and Evaluation (Geographic Information System [GIS])	Summer, 1990

4. Bay of Quinte Remedial Action Plan Decision Making Process

Concurrent with the technical phase of the Bay of Quinte RAP, the Coordinating Committee and PAC have been pursuing a program of public information and education in order to prepare the public-at-large for its role in the decision making process. A chronological summary of the information and education phase of the public involvement program is provided in Appendix A.

A joint Quinte RAP Team - PAC Time to Decide options discussion document has been finalized. It: 1) describes the ecosystem; 2) deals with the Bay of Quinte in terms of nutrient enrichment, bacteria, toxics and habitat concerns; 3) identifies the causative factors; 4) proposes restoration objectives; and 5) identifies the potential remedial measures. The Time to Decide document forms the basis for public dialogue and input into the selection of preferred remedial measures. The decision making process to be undertaken jointly by the Bay of Quinte RAP Coordinating Committee and the PAC will be as follows:

<u>Time to Decide - A Discussion Paper,</u>	September 1989
released jointly by RAP/PAC committees	

Media briefings on options discussion document	September 1989
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Public information meetings	September/October 1989
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RAP/PAC hearings concerning RAP options	November 1989
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RAP/PAC preferred options document	Spring 1990
prepared for public release	

Public meetings concerning preferred	Spring 1990
options document	

5. Where Do We Go From Here

The Stage 1 Report summarizes the key water quality concerns in the Bay of Quinte. Nine impaired beneficial uses and five general pollution concerns are identified. As well, potential corrective actions, data deficiencies and research needs are outlined.

It is the intent of the Bay of Quinte RAP Coordinating and Public Advisory Committees to complete the Stage 2 Report in two parts.

Part 1 will outline the preferred remedial actions for those impaired uses which can be addressed immediately, given the present level of scientific and technical understanding. It will not contain negotiated commitments from those parties responsible for implementation, or a schedule for implementation of remedial actions. Rather, Part 1 will outline, in principle, the parties' commitments to the Bay of Quinte RAP, and will seek IJC approval, in principle, for the proposed plan.

Part 2 will describe the actions needed to: (1) address the "unknown" data deficiencies; (2) summarize information collected and remedial actions identified between submission of Parts 1 and 2; (3) identify future remedial actions; and (4) complete the requirements of the IJC. As well, commitments and an implementation schedule will be key elements of Part 2.

1. INTRODUCTION



1.1 A HISTORICAL PERSPECTIVE

Degradation of water quality in the nearshore waters the Bay of Quinte commenced with the arrival of the United Empire Loyalists in the late 1700s. Soil erosion and nutrient inputs were increased by land clearing activities and logging. Urbanization, and its associated land practices in the late 1800s, also adversely affected the quality of the bay's surface waters. As well, centralized sewage treatment plants installed around 1975 in the larger communities increased the supply of pollutants to the bay, thus, further contributing to degraded water quality (Sly 1986). Lastly, high-phosphate detergents introduced in the bay in the late 1940s and early 1950s contributed additional phosphorus loads (Johnson and Owen 1970). Surprisingly, bay-wide water pollution problems did not peak until well into the twentieth century; possibly, the effects of land-use changes were delayed by a lag in the bay's response time.

In the late 1930s and early 1940s, commercial fishermen noticed accumulations of slime on their nets (probably filamentous algae). Complaints of tastes and odours in municipal drinking water systems were reported in the 1940s. In the 1950s, Eurasian milfoil invaded the bay, largely replacing the native rooted aquatic plants. During the 1960s, blooms of blue green algae developed to nuisance conditions. Algal densities became so severe that other rooted aquatic macrophytes were shaded, and these plant communities, including Eurasian milfoil, all but disappeared (Crowder and Bristow 1986). As a result, an important component of the bay's ecosystem - its habitat for fish and wildlife - was reduced in areal extent and species composition. Other undesirable problems caused by nuisance algal densities included: low dissolved oxygen in bottom waters from decomposing plant material; offensive odours from accumulations of rotting shoreline algae; and, diminished water clarity. At the same time, white perch invaded the Bay of Quinte and lake whitefish, lake herring, walleye, and northern pike were reduced to remnant populations (Hurley and Christie 1977 and Hurley 1986a).

In 1975, the Bay of Quinte was identified as a "problem area" by the International Joint Commission (IJC) owing to its excessive nutrient enrichment, nuisance algal growths, low dissolved oxygen in bottom waters, and localized areas of bacterial and chemical contamination. By 1978, improvements to the waste treatment facilities at Trenton Canadian Forces Base, Trenton, Belleville, Deseronto, Napanee and Picton had reduced municipal phosphorus loadings by about 50%, and water quality conditions had improved. Coincident with these improvements was the emergence of several strong year classes of walleye.

However, rehabilitation has not equalled the abatement efforts, and the water quality concerns persist. For example, algal densities have increased even though phosphorus inputs from municipal sewage treatment plants have declined. Fish habitats have not been improved, and rooted aquatic plants are just now returning to the bay in localized areas. The aquatic community structures are dominated by single species, and thus, the aquatic ecosystem is unbalanced and unstable. Bacterial contamination limits recreational uses of the water, and heavy metals and trace organic contaminants persist in the water, some sediments, and/or fish. These problems threaten life in and around the bay, and prevent rehabilitation and full use of the bay's waters.

The Bay of Quinte was formally identified as an Area of Concern (AOC) by the IJC in 1985. The bay is one of 42 such areas around the Great Lakes for which a Remedial Action Plan (RAP) is being developed. The plan will define the actions and timetables to restore all impaired beneficial uses in each AOC through the implementation of actions to control sources of pollution and by embodying "...a systematic and comprehensive ecosystem approach" (IJC 1987). The plan will also describe the surveillance and monitoring programs needed to assess the plan's effectiveness.

In the summer of 1986, a federal-provincial Coordinating Committee was established to oversee preparation of the Bay of Quinte RAP. One of its first actions was to convene a workshop involving resource managers and

scientists who had been studying the bay since 1976 as part of Project Quinte. The main intent of the workshop was to specify water quality goals and objectives for the bay and identify information gaps. As well, the workshop provided an opportunity to develop a draft format for the RAP, and to consider ways and means of involving the public. An important conclusion was that maximum restoration could be achieved by employing an ecosystem management concept. In other words, the Bay of Quinte was recognized as a complex ecosystem, which could not be restored by actions in isolation of one another; rather, restoration would require a combination of abatement and ecosystem management measures.

In 1987, the Coordinating Committee prepared and distributed the Bay of Quinte Remedial Action Plan Progress Report. This document summarized the present environmental conditions of the bay, confirmed present and future uses, identified the outstanding pollution concerns and some options for restoration, proposed a tentative schedule for preparing the RAP, and identified immediate research needs.

The Progress Report was followed by a number of technical, background reports which are appended as part of this document.

In 1988, a Public Advisory Committee (PAC) was established. The role of the PAC is to assist in preparing the RAP and providing information to the public.

1.2 SCOPE OF THE REMEDIAL ACTION PLAN

As noted above, the RAP for the Bay of Quinte is essentially a framework for action. Coordinated and ongoing direction for responding to environmental problems, from problem recognition to achieving a desired level of rehabilitation, are provided. The RAP for the Bay of Quinte will include:

- . a description of the bay and its related uses;
- . an outline of existing environmental conditions and problems;
- . a description of beneficial uses that are impaired;
- . an analysis of the causes of use impairment;
- . a goal statement and related objectives;
- . the identification and evaluation of remedial actions to restore beneficial uses;
- . a strategy for implementing the RAP, including confirmation of schedules, costs, jurisdictional responsibilities, prognosis, priority evaluation, and stakeholder involvement; and,
- . a process for evaluating remedial measure implementation and effectiveness based on surveillance and monitoring until the restoration of beneficial uses is complete.

The Revised Great Lakes Water Quality Agreement of 1978 (1987) requires the RAP to be submitted to the IJC at three stages:

- . when the environmental conditions have been determined and the causes of the use impairment have been confirmed;
- . when the RAP has been prepared, including the selection of remedial measures; and,
- . when beneficial uses have been restored, based on surveillance and monitoring.

This is the first stage report and is intended to:

- . describe the Bay of Quinte and its environs;

- . outline what is known about past and present environmental conditions, including a description of those beneficial uses that are impaired; and,
- . confirm and evaluate the causes of use impairment, including sources of pollution.

The material has been extracted from numerous background technical reports, government publications, scientific papers and file correspondence. Of particular importance is Project Quinte: Point Source Phosphorus Control and Ecosystem Response in the Bay of Quinte, Lake Ontario (1986). Also important are the results of data collected to confirm both old and emerging problems including: estimates of point (sewage treatment plant and industrial facilities) and diffuse (sediments and urban and agricultural runoff) sources of phosphorus, and zones and/or locations and sources of bacterial pollution, and heavy metal and toxic organic contamination. As well, information is presented on wetlands lost and gained over the years.

1.3 PUBLIC CONSULTATION AND STAKEHOLDER INVOLVEMENT

The Revised Great Lakes Water Quality Agreement of 1978 (1987) indicated that:

"The Parties, in cooperation with State and Provincial Governments, shall ensure that the public is consulted in all actions undertaken pursuant to the Annex."

This general principle recognizes that the public's participation is required to reflect community goals for restoring impaired uses. As well, the Canada-Ontario Agreement (COA) guidelines suggest that public consultation will produce recommendations for water quality restoration which are technically, socially and economically acceptable.

1.3.1 Introduction

The Bay of Quinte RAP public participation process involves three distinct, yet interlocking stages: (1) information distribution - public awareness; (2) education; and, (3) discussion - consultation - input. Each stage logically follows and builds on the information and ideas presented in the preceding stage.

Initially, the Quinte RAP team managed all aspects of public information, education and consultation. With the formation of a PAC in 1988, the aforementioned duties were shared between the two groups. The RAP team continued to distribute information on matters of RAP policy, development and directives, as well as providing technical and background data pertaining to the Bay of Quinte. At the same time, the PAC provided general information about the AOC and its impaired uses, while acting as a parallel technical review team of the RAP.

A chronology of public-stakeholder participation is provided in Appendix A while a summary of media coverage is provided in Appendix B.

1.3.2. Information Distribution - Public Awareness

A number of techniques were employed to distribute information about the Bay of Quinte RAP. These are outlined below.

- In 1986, a "stakeholder mailing list" was established and major stakeholder groups were identified including industry, municipalities and townships, and conservation authorities. The mailing list presently numbers more than 550 stakeholders, individuals and users of the bay.
- Public meetings were held in 1986 to provide details of the RAP process, describe the water quality problems in the Bay of Quinte, introduce the RAP team, and expand the mailing list.
- The Quinte Update newsletter was initiated in 1987. Up to date reporting on recent Quinte RAP activities was provided.
- An information booth is staffed at local events throughout the summer months.
- Public speaking engagements have been ongoing since 1986. Presentations have been given to interest and school groups (elementary, secondary and post-secondary), and environmental organizations.
- Media contacts such as print, radio talk shows and television interviews have been used.
- General information reports: A number of documents have been issued to the stakeholders and are available in the local public libraries. The December 1986 Progress Report and the Bay of Quinte Remedial Action Plan: Progress Report (February 1987) are examples.

1.3.3 Education

This stage requires that the public and stakeholders understand fully the information provided. Many of the techniques employed to distribute information were also used as educational tools. The following additional actions were taken.

- Public meetings were held in 1987 to assist in developing the list of impaired uses, to describe upcoming and ongoing RAP activities, and to define RAPs involvement with other government initiatives (e.g. MISA, Lake Ontario Toxics Management Plan, etc.)
- A questionnaire was used to gauge public awareness and environmental perceptions, and to identify the local water quality concerns.
- Two 3-day ecosystem modelling workshops were held. Members of PAC, local industry and university scientists participated.
- The Quinte RAP sponsored stakeholder and PAC participation at conferences in Washington (1987), Chicago (1988), Kingston (1988), and Toronto (1988).
- Data and technical information was distributed to the public via local libraries, and offices of Environment Ontario, the Ministries of Natural Resources and Agriculture and Food, conservation authorities, and municipalities and townships.
- In October 1988, a day workshop was held with the PAC and interested public. Quinte RAP Chairman Murray German and RAP team member Larry Matheson provided an update on the status of the Quinte RAP and conservation farming techniques, respectively.
- Members of the Quinte RAP team participated in a number of technology transfer workshops to exchange information and promote the RAP

initiative. The workshops include the Soil and Water Conservation workshop - Belleville, and a Water Conservation seminar - Edmonton.

- The RAP team sponsored boat tours of the upper Bay of Quinte and Hay Bay for PAC members and press to examine shoreline developments and problem areas.

1.3.4 Discussion on Consultation Process

The public response to the initial Quinte RAP activities generally was favourable and in agreement with the Quinte RAP team goal and objectives. However, the limitations of the early consultation format, given the amount of technical information available and the varied public expectations, soon became evident. To address this concern, a PAC (or stakeholder committee) was established in December 1987. The intent of the PAC is to serve as a focal point for public consultation and to permit a second review level for the various remedial options. As well, the PAC presented a feasible approach to consensus building among the various interest groups.

A PAC facilitator was hired, and terms of reference for the committee were established (see Appendix C) at a public meeting in January, 1988. As well, committee structure, size and membership were approved. Twenty-one representatives were selected from the following sectors: municipalities, industry, environmental associations, fishing (sport and commercial), Mohawks of the Bay of Quinte, tourism, farming, human health, education and labour.

The PAC meets regularly at different communities throughout the area to review technical information, discuss RAP directions and activities, and promote education. Quinte RAP team members act as resource people at these meetings. This arrangement enhances the exchange of information, and establishes a strong working relationship between the RAP team and PAC.

PAC initiatives include: (1) promoting the protection of the shoreline and wetlands, (2) outlining PAC concerns respecting contaminants in the bay, (3)

development of an educational brochure specific to the Bay of Quinte and (4) sponsoring talks by scientists and staff of other governments agencies and departments.

1.3.5 Upcoming Activities

A discussion paper, Time to Decide, on the remedial options has been prepared by the RAP and PAC teams, and distributed to stakeholders. The topics include phosphorus control, bacteriology, toxic contaminants and physical habitat. During the review period, a number of public openhouses/information sessions were held throughout the watershed. Quinte area stakeholders and residents who attended discussed the report with members of the Coordinating Committee and PAC. As well, the PAC will be meeting in separate sub-committees during the review period to further study and consider the pros and cons of the various options.

Following the review, a public hearing chaired jointly by the Bay of Quinte Coordinating Committee and PAC was held. Members of the public and interest groups had an opportunity to express their views and opinions concerning the options to improve the Bay of Quinte's ecosystem. The PAC is reviewing this information, and a final meeting with the Coordinating Committee and PAC is needed to finalize the preferred options.

A final series of meetings is planned to outline to the public the preferred options and the rationale for selecting them. With these meetings, the consensus building process will have been completed, thereby clearing the way for preparation of the Stage 2 Bay of Quinte RAP.

2.1 LOCATION AND EXTENT

The Bay of Quinte, a Z shaped bay on the northeastern shore of Lake Ontario, is approximately 100 km long and 254 km² in area (Figure 1). It is largely separated from the lake by Prince Edward County and Amherst Island. The bay's watershed totals 18,200 km²; the northern one half is Precambrian Shield and the remaining southern portion is Paleozoic limestone (Figure 2). Four major rivers empty into the bay from the north including the Trent River which drains most of the watershed (i.e., 12,600 km²), the Moira River draining 2,7800 km², and the Salmon and Napanee Rivers which together drain about 1,600 km². The maximum width of the bay is about 3.5 km, and there are major points of constriction at Belleville, Telegraph Narrows and Glenora.

The Bay of Quinte can be subdivided into three smaller sub-units: the upper, middle and lower bays.

The upper bay consists of several connected bays and extends from Trenton eastward to the end of Long Reach near Deseronto (Figure 1). The north shore of the upper bay supports a population of about 60,000, mainly in the urban centres of Trenton, Belleville, the Town of Deseronto and the Town of Napanee on the Napanee River. The middle bay consists of the area between the end of Long Reach, and Glenora and includes Hay Bay, a shallow expanse draining the Wilton Creek watershed. The lower bay consists of the waters northeast of Glenora, past Conway and the Lennox Generating Station and past the shallow sill at the Upper Gap to the shallowest point halfway along Amherst Island. The lower bay is known locally as Adolphus Reach. About 15,000 people reside in the Town of Picton and townships surrounding the middle and lower bays (Johnson and Hurley 1986).

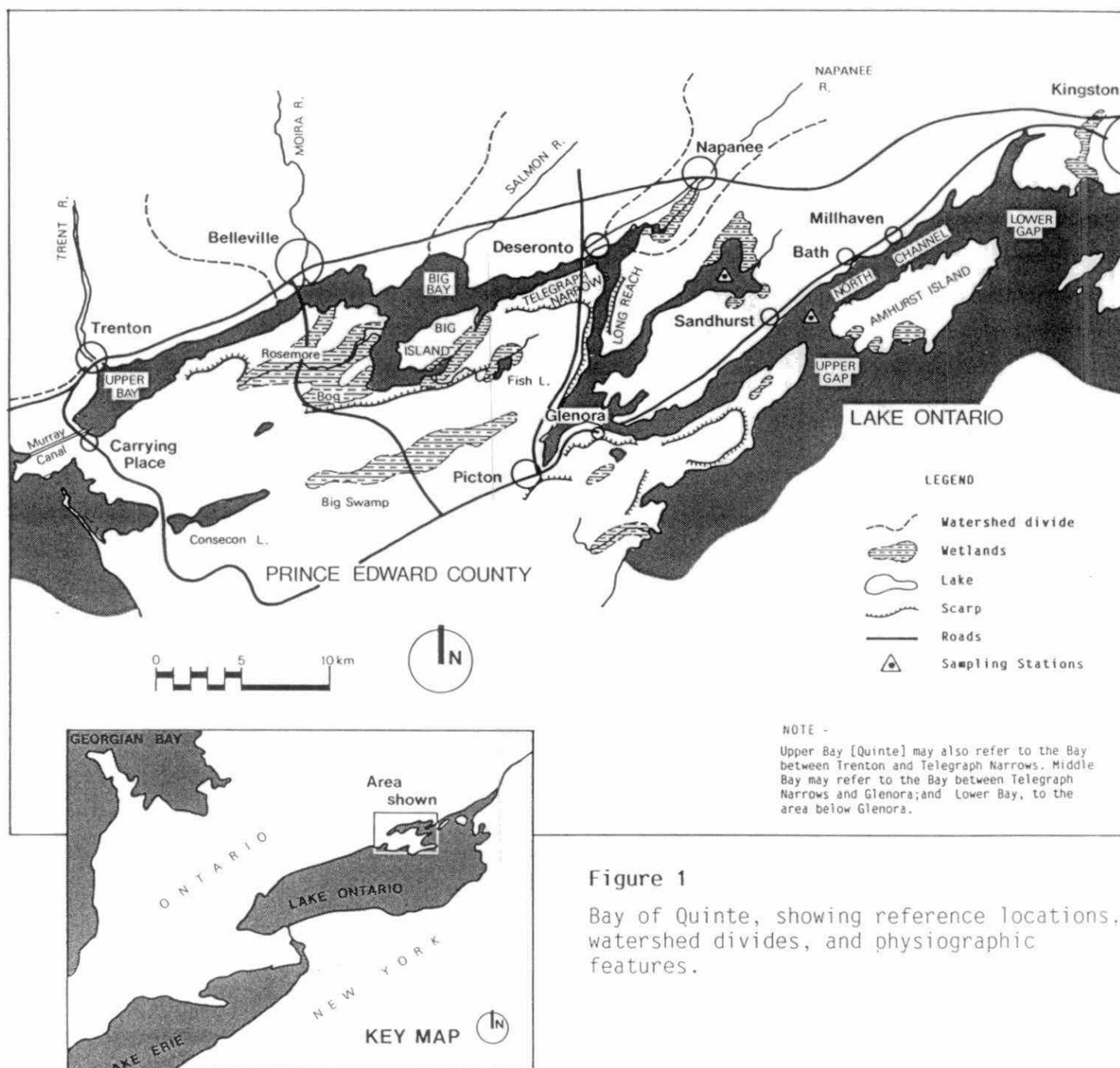


Figure 1

Bay of Quinte, showing reference locations, watershed divides, and physiographic features.

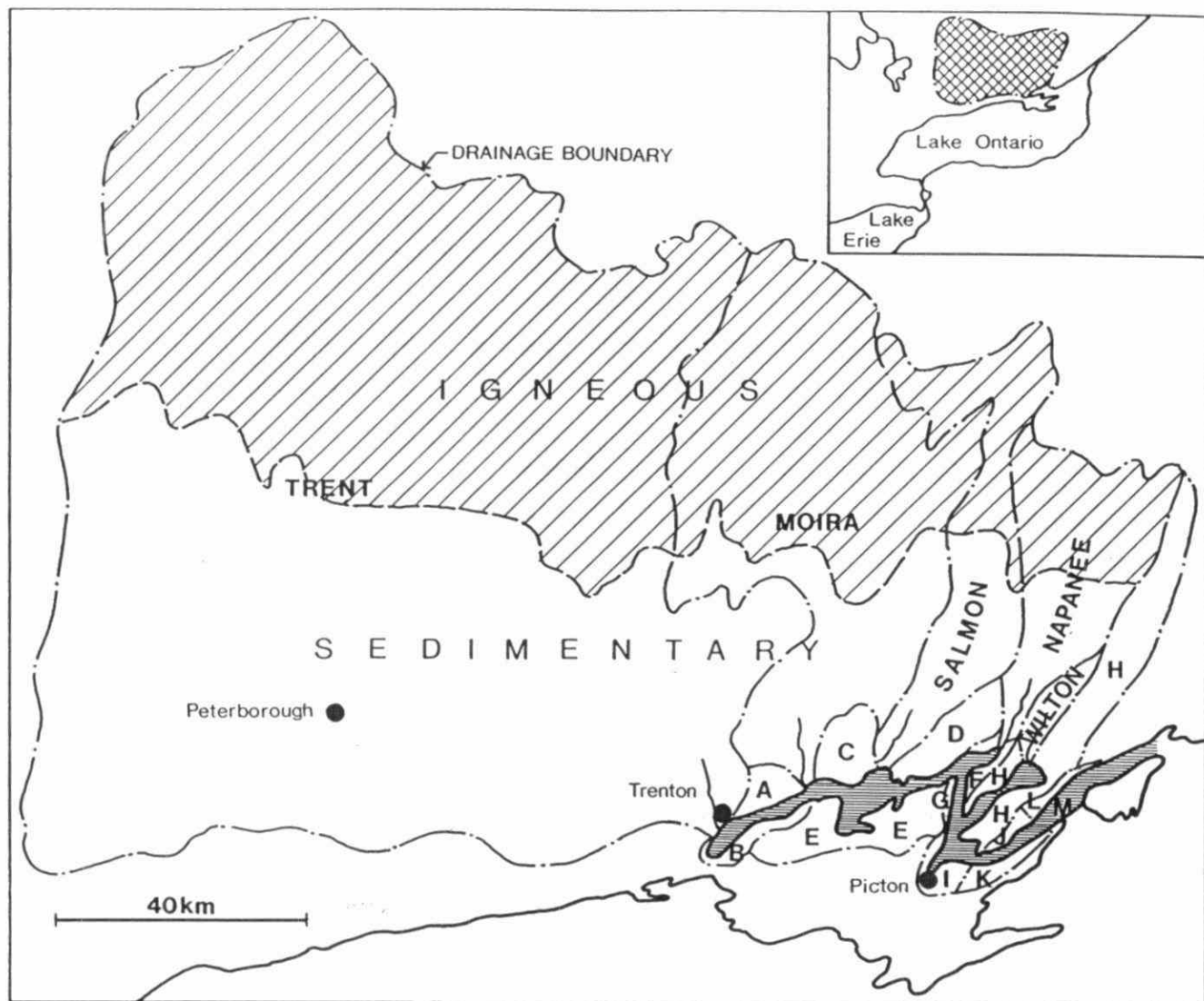


Figure 2. Drainage basin of the Bay of Quinte, with the drainages of the major rivers and the many miscellaneous areas delimited (crosshatching for igneous rock forms). Related land use details are shown in Table 3 (from Minns et al. 1986).

The Upper and Lower Gaps connect the lower bay with eastern Lake Ontario. The Upper Gap, is 2.4 km wide and 13 m in depth, and the eastern passage, or Lower Gap, is of similar width, but twice as deep. The Murray Canal connects the western end of the Bay of Quinte to Lake Ontario; the canal is 8 km in length, 23 m in width and 3 m in depth.

Two cities (i.e., Belleville and Trenton), three towns (i.e., Napanee, Deseronto and Picton), and 12 townships are within three counties (i.e., Hastings, Lennox and Addington, and Prince Edward) which border the Bay of Quinte. A very small part of Northumberland County fronts the bay's extreme western shoreline.

2.2 CLIMATE

2.2.1 General Conditions

Mean annual temperatures in the Bay of Quinte watershed are about 6°C, with an extreme range between about -36°C and 19°C. Mean daily maxima and minima are about -6°C and -13°C in January, and 27°C and 14°C in July. The area has about 140 frost free days, and ice cover usually begins to form over the bay in late December. Recorded mean precipitation is about 850 mm/yr-900 mm/yr, over much of the bay's watershed, with few annual minima less than 700 mm/yr, and most maxima less than 1,100 mm/yr.

2.2.2 Air Temperature

Using data from Kingston and Trenton, Sly (1986) illustrated changes in the means of annual, summer (June, July and August) and winter (December, January and February) mean air temperatures for the 1880 to 1980 period (Figure 3). The data indicated that:

- . the 10-year annual mean peaked about 1950;
- . the decadal summer high peaked around 1940;
- . winter temperatures showed greater variation about the mean than did summer temperatures; and
- . April temperatures, used as a correlate of spring melting, exhibited considerable year-to-year variation.

2.2.3 Precipitation

Mean annual summer (June, July, and August) and winter total precipitation are shown in Figure 4. The March data have been included to emphasize the water source for spring runoff (Sly 1986). The following are highlights:

- . a significant peak occurred in the early 1950s;
- . the decadal mean summer precipitation which varied from about 192 mm to 235 mm showed little departure from the long-term mean;
- . the range of decadal means in winter precipitation was between 200 mm and

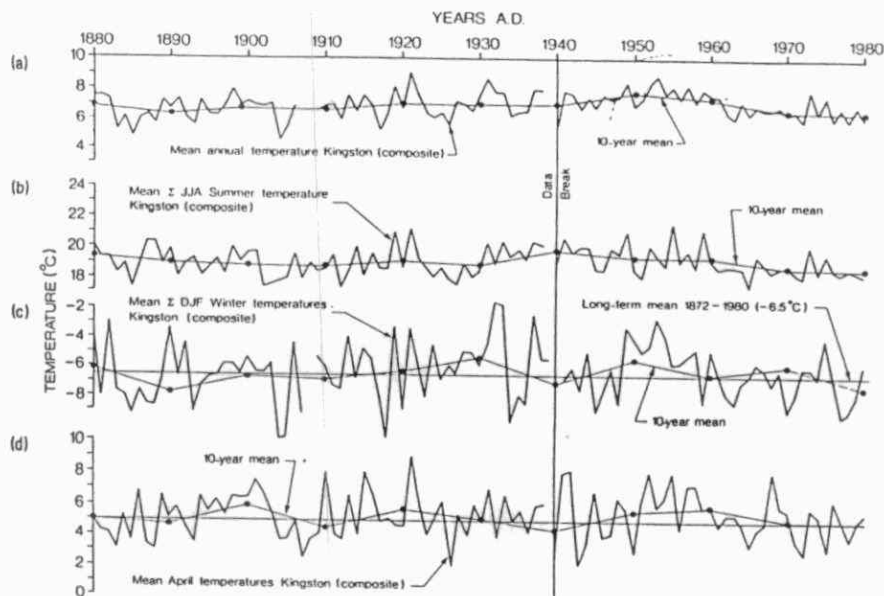


Figure 3. Mean annual temperature (a); summer (June, July and August) mean temperatures (b); winter (December, January and February) mean temperatures (c); and mean April temperatures. All data are Kingston composite data (from Sly 1986).

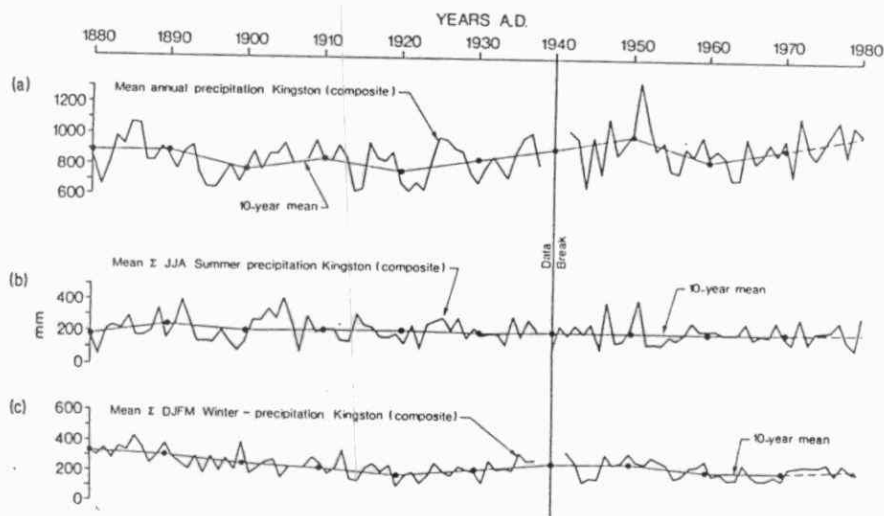


Figure 4. Mean annual precipitation (a); sum of summer (June, July and August) mean precipitation (b); and sum of winter and early spring (December, January, February and March) mean precipitation (c). All data are Kingston composite data (from Sly 1986).

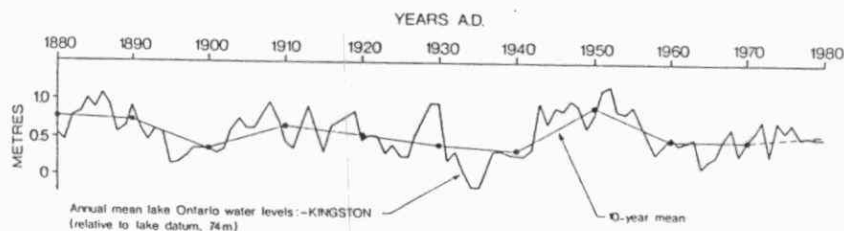


Figure 5. Lake Ontario recorded water levels (from Sly 1986).

320 mm, and while there was little variation about the long term mean, it was greater than those observed for the summer data; and
. low winter precipitation occurred between 1910 and 1930 and 1960 and 1970.

2.2.4 Significance of Climatic Change

During the past 50 years, mean annual temperatures have probably been as warm as at any time in the past 2,500 years. Even though long-term recorded climate appears to be relatively stable, short term fluctuations and events have significant effects on environmental conditions. For example, warm early spring temperatures can enhance the hatch and growth of zooplankton, and thus, impact on the availability of food supplies for fish species. Cold, early summer temperatures of the early 1960s, have had an adverse impact on white perch survivability (Sly 1986). Other species such as lake whitefish have benefitted from combinations of cold falls and warm springs (Christie 1963; and Christie and Regier 1973). The high periods of maximum water level variations between 1882 and 1891, 1903 and 1920, 1927 and 1930, and 1942 and 1957 (Figure 5) might have modified water quality in the upper bay, and thus, "...changed the use of fish spawning habitats and the structure of wetland areas" (Sly 1986). Lastly, the combination of high winter precipitation and warm spring temperatures were causative factors in the floods of 1886 and 1936, while floods in 1885 and 1981 were the result of ice jams at the mouth of the Moira River (Moira River Conservation Authority, 1950).

The short-term effects of precipitation and stream flows also have substantial influences on water quality conditions in the bay.

Poor water quality generally occurs during periods of low flows between May and September (Table 1), that is, low summer flows do not completely dilute or flush the pollution loading at these times. Sly (1986) concluded that in recent years, low summer precipitation and related low flows and flushing rates are the largest natural factors impacting on trophic conditions in the Bay of Quinte.

Table 1. Drainage areas and flows for specified periods of major rivers discharging into the Bay of Quinte (reproduced from Sly 1986).

	River				Remarks
	Trent	Moira	Salmon	Napanee	
Area (km ²)	12,940	2,840	900	840	-
Annual mean flow (m ³ /s) predicted from area discharge (Ongley, 1973)	122	27.2	84.7	8.1	-
Annual mean flow (m ³ /s), measured	90.1	29.9	-	9.1	-
Maximum mean daily flow (m ³ /s) measured	567	351	104	96	Floods
Maximum mean monthly flow (m ³ /s) April measured	206	116	-	37	High spring flow
Minimum mean summer flow (m ³ /s) July-September measured	36.8	5.4	-	1.7	Low flow

2.3 TERRAIN CHARACTERISTICS

2.3.1 Bedrock Geology

The drainage basin of the Bay of Quinte includes large areas of land underlain by sedimentary bedrock types formed during the Phanerozoic, as well as an extensive area covered by various igneous, volcanic, and metamorphic rocks of Precambrian age (Hewitt 1972 and Freeman 1979). The contact zone between these two broad formations essentially divides the basin into northern and southern halves (Figure 2).

Sedimentary bedrock belonging primarily to the Trenton and Black River groups constitutes most of the cover from the Kawartha Lakes environs southward to Lake Ontario. The bedrock throughout this area consists of limestones, dolostones, and shales formed during the Middle Ordovician era approximately 445 million years ago (Poole et al. 1972). In the southwestern portion of the basin, the bedrock is overlain by relatively deep layers of glacial drift material; however, the overburden becomes progressively thinner northward and eastward. The incidence of bedrock outcropping increases near these limits, providing favourable opportunities for quarrying. Limestone was in fact quarried extensively for building stones in the immediate vicinity of the Bay of Quinte (i.e., at Belleville and Picton) and points eastward, as well as to the north at Coboconk for lime (Hewitt 1972).

The northern portion of the basin consists primarily of middle Precambrian (circa 1600 to 2600 million years old) to late Precambrian (570 to 1600 million years old) bedrock types. These include a relatively wide variety of rocks such as conglomerates, granites, gneisses, diabases, greywackes, etc. (Freeman 1979). Due to the general shallowness of the glacial drift, bedrock exposures are common throughout this portion of the basin.

2.3.2 Geomorphology and Physiography

The Bay of Quinte drainage basin includes parts of many of the prominent

physiographic units of central and southern Ontario. The distinctive landforms that describe these units all originated from glacial and, to some extent, post-glacial events during the advance and recession of the Wisconsin ice sheet.

Essentially, the entire northern portion of the basin coinciding with the distribution of Precambrian bedrock types consists primarily of shallow till over rock ridges with frequent rock exposures. The only deep deposits are local sand plains and spillways (Chapman and Putnam 1984).

The southern side of the contact zone is marked by local limestone plains which occur locally, but more or less continuously, from Balsam Lake in the west to Lennox and Addington County in the east. Limestone plains also extend southward from the latter into adjacent Hastings and Prince Edward Counties. Two major moraine systems span much of the southern part of the basin. The Dummer till moraine runs eastward from Balsam Lake, bordering the Kawartha system, and extending to southern Lennox and Addington County. The Oak Ridges kame moraine, which runs parallel to and just a few kilometres inland from Lake Ontario, essentially represents the southern boundary of the basin. The land occurring between these two moraines consists primarily of drumlinized till plains interspersed with sand and clay plains, spillways, and recent organic deposits.

The immediate vicinity of the Bay of Quinte lies within the Prince Edward County and the Napanee Plain physiographic units. The former is described primarily as a limestone plain; however, deep clay beds, which support much of the agricultural activity in the unit, occur along significant portions of the shoreline. Part of the north shore consists of drumlinized till, with drumlins occurring locally throughout. The Napanee Plain also consists of prominent limestone beds, but the local clay deposits are generally shallow. Drumlins similarly occur sporadically in this unit (Chapman and Putnam 1984).

2.3.3 Relief

The topography of the basin reflects the distribution and character of the overburden materials and bedrock. Relief is generally subdued within limestone and clay plains, such as those dominating the immediate vicinity of the Bay of Quinte. However, the terrain is decidedly more vigorous on the moraines and drumlins through much of the southern parts of the basin, as well as in the areas dominated by Precambrian bedrock ridges.

2.3.4 Soils

The broad associations constituting the soil cover in the basin coincide closely with the pattern of glacial deposits which essentially represent the parent materials. The soils of the northern portion consist almost entirely of shallow loamy sands that are characteristically strongly acidic throughout. South of the contact zone, the cover is somewhat more variable. The major soil associations occurring in the basin are indicated in Table 2.

In general, loams dominate over most of the till plains, limestone plains and moraines, although sandy loams occur extensively on the Oak Ridges moraine. Clays are prominent in the immediate vicinity of the Bay of Quinte, as well as in scattered localities elsewhere in the southern parts of the basin.

Table 2. Soil association characteristics and physiographic unit relationships in the Bay of Quinte drainage basin (Hoffman, Matthews, and Wicklund [1964]).

Physiographic Unit	Soil Association	Reaction	Drainage
Limestone plains	Farmington loams	neutral	variable
Dummer moraine	Osprey loams	neutral	good
Oak Ridges moraine	Fox sandy loam	slightly acidic	good
drumlinized till plain	Otonabee loam	neutral	good
	Guelph loam	slightly acidic	good
Clay plains	Haldimand clay	medium acid	imperfect
	Lincoln clay	slightly acidic	poor
	Rideau clay	medium acid	imperfect

2.4 VEGETATION

2.4.1 Regional Characteristics

The vegetation of Canada has been classified into eight major forest regions, or formations, based on the specific compositional characteristics and distribution patterns of the cover. These formations reflect responses to broad climatic regimes. Within each region, distinct sections have been delineated according to local vegetation patterns resulting from various combinations of physiographic, geologic, edaphic, or microclimatic influences (Rowe 1972).

The Bay of Quinte drainage basin includes portions of two formations: the deciduous forest region which is restricted to the immediate shoreline of Lake Ontario, and the Great Lakes-St. Lawrence forest region which covers the majority of the basin. Within the latter, the basin spans parts of three sections: the Huron-Ontario section, which covers most of the lower reaches south of the Precambrian-Ordovician contact zone, including all of the Kawartha Lakes and the Trent River system; the Georgian Bay section, which covers the northwestern portion above the contact zone, including parts of Haliburton; and, the Middle Ottawa section, which dominates the northeastern portion. The characteristics of each formation and section are described briefly below.

2.4.2 Deciduous Forest Region

As the name suggests, the dominant tree cover in this region consists of deciduous hardwood species, primarily sugar maple (Acer saccharum), beech (Fagus grandifolia), basswood (Tilia americana), red maple (A. rubrum), red oak (Quercus rubra), white oak (Q. alba), white ash (Fraxinus americana), and white elm (Ulmus americana). Due to the moderating influence of Lakes Huron, Erie and Ontario, more southerly distributed species, such as shagbark (Carya ovata) and bitternut hickory (C. cordiformis), black walnut (Juglans nigra), butternut (J. cinerea), and sycamore (Platanus occidentalis), also occur

sporadically. Due to the long period of human occupation, and favourable climate and soils, most of the forest cover of this region has been cleared for agricultural activities. Stands now exist primarily as local woodlots on sites too difficult to develop, such as in valleys or areas where soils are too wet or rocky.

2.4.3 Great Lakes-St. Lawrence Forest Region

Huron-Ontario Section: The lower limits of this region about the northern boundary of the deciduous forest region; consequently, many of the species noted above continue to be prominent in this section. These include sugar maple, beech, basswood, white ash, red oak, and white oak. A number of species of southern affinity reach their natural northern range limits in this section, including, sycamore and black walnut. However, conifers, such as white pine (Pinus strobus), hemlock (Tsuga canadensis), white cedar (Thuja occidentalis), and balsam fir (Abies balsamea), are also prominent, often forming coniferous stands or sharing dominance with deciduous species in mixed stands. As is the case for the deciduous forest, much of the natural cover has been cleared for agriculture; consequently, forest stands are now distributed sporadically through the region.

Georgian Bay Section: The forest cover of this section marks the predominance of broad mixtures of deciduous and coniferous species. The major trees include sugar maple, red maple, white ash, beech, basswood, yellow birch (Betula lutea), hemlock, and white pine; however, boreal tree species, such as white spruce (Picea glauca), also occur locally on colder sites. As all of this section lies on Precambrian bedrock, the forest cover has generally remained intact except for local townsite clearings.

Middle Ottawa Section: Most of the tree species that dominate the previous section (i.e., sugar maple, beech, yellow birch, red maple, hemlock, and white pine) form the cover here as well; however, deciduous species appear to be generally more abundant, particularly in the southern parts. Hardwood swamps dominated by black ash (F. nigra), red maple, and white elm, and

conifer swamps dominated by white cedar, occur relatively frequently. Although much of the southern parts have been cleared for agriculture, the cover in northern areas has remained relatively undisturbed.

2.5 LAND USES

Information on land uses within the watersheds and miscellaneous areas draining to the Bay of Quinte are presented in Figure 2 and Table 3. About 60% of the watershed is forested, 37% is agricultural, 3% is marsh and/or swamp and 1% is urban.

2.5.1 Agriculture

Agriculture is a significant part of the Bay of Quinte economy; more specifically, about 9% of the total workforce is employed in agricultural activities. There are 1,351 farms in Hastings County covering 134,776 ha (22.6% of the county). Prince Edward County has 629 farms on 63,784 ha (61% of the total land area). Lennox and Addington County possesses 761 farms on 83,595 ha (29% of the total land area), (Statistics Canada 1985).

Prince Edward County possesses the highest amount of improved farmland (42%), while Lennox and Addington and Hastings have 16% and 11% respectively.

A high proportion of agricultural activities (63-84%) are concentrated on the sedimentary terrain adjacent to the bay. The emphasis is row cropping (mainly corn production), dairy herdings, cattle and pigs.

Between 1976 and 1986, row cropping had increased by 34% in Northumberland County, Hastings County, and Lennox and Addington County. For about the same time period, total cattle units declined by 21%, while total hog units increased by 92%. Overall, total animal units decreased from approximately 180,000 units in 1975 to 151,000 units in 1985. This is consistent with the observed increases in row crop densities in the watershed (Ecologistics Limited 1987).

2.5.2 Urban Areas

Major service, trade and population centres include Belleville (population 36,000) and Trenton (population 15,000). Both cities are located along the

Table 3. Drainage areas and their land uses around the Bay of Quinte (derived from Lands Management Information Systems/Lands Directorate, Environment Canada, and reproduced from Minns et al. [1986]).

Drainage ^a		Area (km ²)	% Urban	% Agriculture	% Forest	% Swamp/marsh
Upper bay	Trent River	12,548.7	0.9	36.1	59.7	1.9
	Miscellaneous A	114.5	11.2	68.9	17.1	
	Miscellaneous B	21.8		74.5	21.4	4.2
	Moirs River	2,737.2	0.6	26.6	69.4	2.9
	Salmon River	897.5	0.4	31.9	62.7	3.1
	Miscellaneous C	110.0	7.2	69.9	19.5	
	Miscellaneous D	215.6	1.1	83.5	14.3	1.2
	Miscellaneous E	231.8	0.1	63.1	28.0	8.4
	Napanee River	787.0	1.1	40.5	56.2	2.0
	Miscellaneous F	28.1				
	Miscellaneous G	12.6		67.4	28.2	4.4
Middle bay	Willow Creek	127.4	0.3	74.5	23.3	2.0
	Miscellaneous H	220.0				
	Miscellaneous I	44.8	8.7	64.7	25.8	
Lower bay	Miscellaneous J	22.9		82.6	17.4	
	Miscellaneous K	34.3		71.3	22.6	1.4
	Miscellaneous L	22.0		82.6	17.4	
	Miscellaneous M	5.5		77.9	19.3	2.7
Total		18,181.6	1.0	37.1	58.7	3.3

Locations of miscellaneous drainage areas are shown on Figure 2

north shore of the upper Bay of Quinte. Intermediate centres include the towns of Napanee (population 7,500), Picton (population 4,200) and Deseronto (population 849). There are also numerous smaller villages and hamlets scattered throughout the area (Ecologistics Limited 1989). Population statistics for the centres and the twelve townships bordering the bay are shown in Table 4. Between 1976 and 1986 population growth averaged about 2.2%, which is consistent with the Ontario government's projection of little growth in the area to 2001 (Table 5).

The bulk of industrial land use is concentrated in Belleville and Trenton. Belleville houses 118 manufacturing operations while Trenton has 94. Manufacturing activity in these two centres is outlined in Table 6. Besides the "other major group" category, the food and beverage industry accounts for the highest percentage of manufacturing in both centres.

Manufacturing related occupations occupy a large portion of the total work force: Hastings County has 19.1% of its population involved in manufacturing, Lennox and Addington County 18.2%, and Prince Edward County 15.1%.

Manufacturing activity is on the upswing in the Bay of Quinte area. After a considerable period of economic decline (Trushinski 1986), the area experienced modest manufacturing growth in 1988, which has continued in 1989.

Table 4. Population densities for cities, towns and townships surrounding the Bay of Quinte. All data are from Statistics Canada (1982 and personal communication).

	Population			Change (% per year)		
	1976	1981	1986	1976-1986	1976-1981	1981-1986
Cities						
Belleville	35,311	34,881	36,041	+0.20	-0.24	+0.66
Trenton	15,476	15,085	15,311	-0.10	-0.50	+0.29
Towns						
Deseronto	1,909	1,746	1,881	-0.14	-1.70	+1.54
Napanee	4,844	4,803	4,803	-0.08	-0.17	n.c.
Picton	4,649	4,177	4,235	-0.89	-2.03	+0.27
Townships						
Adolphustown	691	686	777	+1.24	-0.14	+2.65
Ameliasburgh	4,903	4,934	5,070	+0.34	+0.13	+0.55
Hollowell	4,438	4,342	4,428	-0.02	-0.43	+0.39
Murray	6,069	5,994	6,117	+0.07	-0.24	+0.41
North						
Fredricksburgh	2,801	2,684	2,795	-0.02	-0.83	+0.83
South						
Marysburgh	1,210	1,129	1,183	-0.22	-1.34	+0.95
Richmond	3,348	3,532	3,600	+0.75	+1.09	+0.38
Sidney	15,307	16,108	16,263	+0.62	+1.04	+0.19
Sophiasburgh	1,872	1,897	1,830	-0.22	0.26	-0.71
South						
Fredricksburgh	1,180	1,107	1,117	-0.53	-1.23	+0.18
Thurlow	6,150	6,555	6,688	+0.87	+1.30	+0.40
Tyendinaga	2,625	2,661	2,714	+0.33	+0.27	+0.39
Tyendinaga Reserve	1,029	1,037			+0.15	

n.c.- no change

Table 5 Projected population trends for Hastings, Prince Edward and
 Lennox and Addington Counties (Ontario Ministry of Treasury
 and Economics 1982).

	Population				Change (% per year)
	1976	1981	1986	2001	
Hastings	105,837	106,885	114,219	122,008	+0.06
Prince Edward	22,559	22,335	22,847	22,505	n.c.
Lennox and Addington	32,633	33,040	33,713	34,162	+0.18

n.c. - no change

Table 6. Manufacturing activity in Belleville and Trenton (Statistics Canada 1985)

Type of Establishment	Number of Establishments	Percent of Total
Belleville		
Food Industry	18	15.3
Textile Production	4	3.4
Clothing Industry	3	2.5
Wood Industry	11	9.3
Furniture and Fixture	4	3.4
Printing, Publishing and Allied Industries	13	11.0
Fabricated Metal Production	13	11.0
Other Groups	<u>52</u>	44.1
TOTAL	118	
Trenton		
Food Industry	18	19.2
Leather and Allied Products Industries	5	5.3
Wood Industries	17	18.0
Furniture and Fixture	4	4.3
Fabricated Metal Products Industries	9	9.6
Transportation	3	3.2
Other Major Groups	<u>38</u>	40.4
TOTAL	94	

2.5.3 Wetlands

Wetlands provide habitat for fish, waterfowl and wildlife, and recreational opportunities for humans. They constitute an extensive and significant natural element of the Bay of Quinte shoreline and adjacent lands. However, the existing cover represents only a relatively small proportion of the original extent. Many large shoreline complexes in the watershed have been drained, mainly to increase the agricultural land base, at the expense of fish and wildlife habitat and water quality.

Recently, Environment Canada prepared a series of maps illustrating current distributions in southern Ontario. As well, an attempt was made to document wetlands lost prior to and after 1967, and wetlands gained since 1967. This information base was used to determine the present status and type of wetland in the immediate area of the Bay of Quinte. Because of the large extent of the watershed, the analysis was restricted to the immediate vicinity of the bay (i.e., to within 3.2 km of the shoreline).

In addition, an examination of recent (1983) aerial photographs of the area was undertaken to identify the general land use changes that have occurred through wetland drainage activities. The results of this analysis are presented in Table 7 and summarized below.

Lost Wetlands: Within 3.2 km of the Bay of Quinte's shoreline, an estimated 12,008 ha of wetlands, including both wooded and emergent community types, were lost prior to 1967. Conversion to agriculture probably accounted for over 90% of this loss, with residential development and a few local sand and gravel pits constituting the remainder. Most of the losses occurred on the north side of the bay. Between 1967 and 1982, a further 419 ha of wetlands were lost, again primarily to agricultural development, and mostly on the north side of the bay.

Current wetlands: Approximately 6,745 ha of wetlands remain in the immediate vicinity of the Bay of Quinte, including 2,508 ha of swamps, and 3,818 ha of

Table 7. Summary statistics (areas in ha) for existing and lost wetlands within 3.2 km of the Bay of Quinte shoreline.

Substrate Classes	Wetlands lost up to 1967	Wetlands lost from 1967-1982		Current Wetlands		Wetlands Gained 1967- 1982
		Thicket	Emergent	Thicket	Emergent	
0: organic			53	521	2,037	
W: water- covered		-	-	-	70	
2: fertile medium - texture		37	-	36	-	
3: medium fertility, clay	12,008	166	-	1,304	17	542
4: low fertility, sand		-	-	-	-	
5: low fertility, sand, gravel		8	-	158	8	
6: very low fertility, shallow soil/ rock		-	-	-	-	
7: very low fertility, very poor drainage		68	77	355	467	
8: unknown		10	-	134	1,219	
Subtotals	12,008	289	130	2,508	3,818	542
Totals	12,427			6,745		542

emergent community types. These are generally evenly distributed throughout the area. Along the south shore, the largest complexes occur around Muscote Bay; the largest blocks on the north shore occur at Hungry Bay and Hay Bay.

Gained wetlands: Since 1967, about 542 ha of wetland communities have been gained. These are distributed sporadically throughout the area, with the largest blocks occurring just east of Belleville. All of these communities occur in areas that were lost to agriculture prior to 1967, as determined through air photo interpretation.

2.5.4 Industrial and Resource Related Uses

Locations of industries that discharge directly to the Bay of Quinte and landfill sites are shown in Figure 6. Further information on industrial discharges is provided in Section 2.6.7, while details on landfill sites are summarized below.

Domestic, commercial and industrial wastes have historically been disposed of in dumps, sanitary landfills and industrial waste disposal sites in the Bay of Quinte region. Although several are still in operation, restrictions are in effect on the amount and type of wastes which may be disposed of at each site. Generally, only domestic, commercial and inert industrial wastes are accepted for disposal at landfills, while hazardous industrial wastes are transported to facilities which are licensed for this purpose. No operating sites in the Bay of Quinte area are licensed for disposal of hazardous industrial wastes.

28 sites were classified as follows:

Bulky waste disposal sites: These accept wastes such as earth, rock, brush and timber at rates less than 150 tonnes/annum (Table 8). Most sites are within 200 m of surface waters, and are not likely to have a significant impact in the Bay of Quinte because of the relatively inert nature of their wastes.

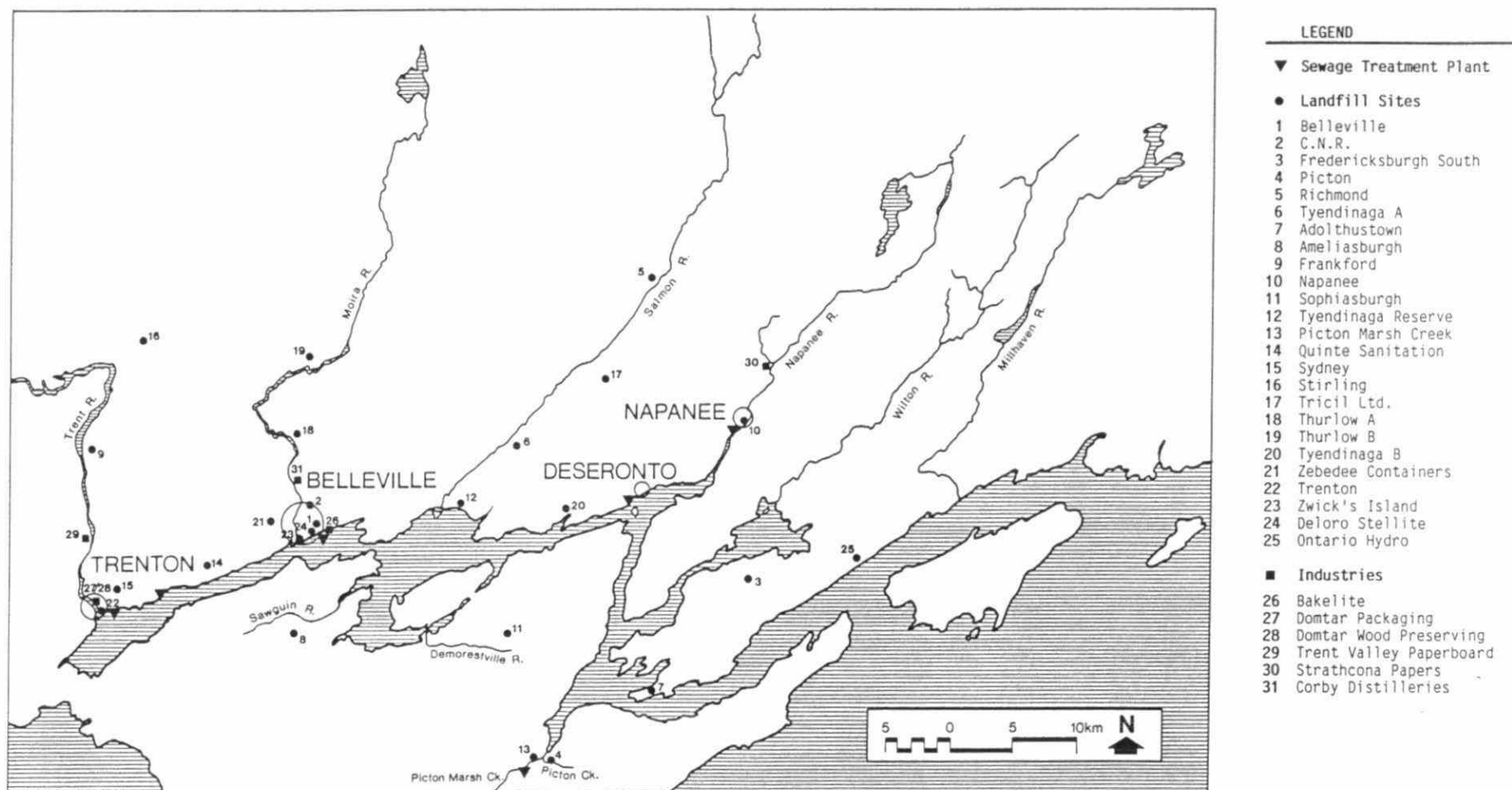


Figure 6. Locations of landfill sites, sewage treatment plants and industries, Bay of Quinte (from Beak 1989a).

Table 8. Bulky waste sites in the Bay of Quinte area (from Beak 1989a).

Site	Status (Open/ Closed)	Start-up Date	Area (ha)	Disposal Rate (tonnes/yr)	Waste Types	Burning (Yes, No)	Distance to to Nearest Water Course (m)	Distance to Bay of Quinte (m)
Belleville	O	1971	0.81	20	earth, rock, rubble	N	50 - Bay of Quinte	50
CNR	C	1971?	0.42	130	wood, sand, gravel, cardboard, cement, wire	N	15 - swamp	3,000
Fredericksburgh South	O	1971	0.2	22	brush, lumber, non- putrescible bulky items	Y	750 - Lloyst Creek	1,000
Picton	O	1955	0.3	95	brush, lumber, tires	Y	200 - stream	1,000
Richmond	O	1973	6.1	130	brush, lumber, non- putrescible bulky items	Y	1,500 - Napanee River	9,600
Tyendinaga	O	1967	1.0	30	brush, lumber, non- putrescible items	N.I.	150 - Salmon River	7,300

N.I. - no information

Inland municipal landfills: The sites presented in Table 9a are inland with respect to the Bay of Quinte and have either received or are receiving only commercial and domestic wastes, whereas those listed in Table 9b have historically accepted industrial as well as domestic and commercial waste. Industrial wastes disposed of include unspecified liquids, pesticides, petroleum-contaminated soils and non-hazardous packaging materials. With one exception (i.e., Stirling), all landfills listed in Tables 9a and b are at least 15 years old and are within 500 m of surface waterways. Depending on groundwater velocity, soil type, and attenuation of contaminants, leachate plumes could be intersecting surface water streams, either at present or in the future.

Shoreline landfills: The two shoreline landfills have been closed, covered and revegetated (Table 10). At both sites, bermed cells were constructed along the bay's shoreline using broken limestone and fine-gravel fill material, and the wastes were backfilled within the cells. The construction materials are not considered to be impermeable to water flows. Data on leachate are minimal; however, samples obtained within a landfill cell at the Zwick's Island site contained up to 2 mg/L phenols and coliform bacteria up to 360,000/100 mL.

Industrial waste disposal sites: Information on the four sites are summarized below and in Table 11. All are small and are located on the property of the industry serviced; two sites, Ontario Hydro and the Domtar Packaging, are open.

Domtar Packaging disposes of wood and paper wastes in a landfill, and black liquor sludge in a clay-lined and bermed lagoon. The wood and paper wastes decompose slowly, releasing organic chemicals to both ground and surface waters; these organics are not likely to be toxic. The black liquor sludge has not been chemically characterized; accordingly, potential water quality impacts cannot be addressed. However, the sludge is stored in clay-lined lagoons, and migration is possible because clay is not impervious to flow (Beak 1989a).

Table 9a. Inland municipal landfill sites in the Bay of Quinte area which have accepted/are accepting commercial and industrial wastes (from Beak 1989a).

Site	Status (Open/ Closed)	Start-up Date	Area (ha)	Disposal Rate (tonnes/yr)	Waste Types (%)			Distance to Nearest Water Course (m)	Distance to Bay of Quinte (m)	Evidence of Leachate
					Commercial	Domestic	Other			
Adolphustown	C	N.I.	0.4	1,095		100		185 - Bay of Quinte	185	N.I.
Ameliasburgh	O	1967	2.5	3,100	5	85	10 - wood	45 - creek	4,400	surface spring
Frankford	O	1970	6.6	800	30	67	3 - brush, lumber	500 - Trent River	12,500	none
Napanee	C	N.I.	1.0	N.I.	N.I.	N.I.	N.I.	about 20 - Napanee River	5,000	drainage ditches, springs
Sophiasburgh	C	1971?	2.0	N.I.		100		182 - Fish Lake	does not drain to bay	N.I.
Tyendinaga Reserve	O	pre-1960	1.0	N.I.	10	90		300 - Sucker Creek	1,000	springs toe of mound

N.I. - no information

Table 9b. Inland landfill sites in the Bay of Quinte area which have accepted/are accepting industrial wastes (from Beak 1989a).

Site	Status (Open/ Closed)	Start-up Date	Area (ha)	Disposal Rate (tonnes/yr)	Waste Types (%)			Distance to Nearest Water Course (m)	Distance to Bay of Quinte (m)	Evidence of Leachate
					Commercial	Domestic	Industrial and other			
Picton Marsh	C	early 1960's	7.3	N.I.	N.I.	N.I.	possibly industrial	0 - Marsh Creek	460	impact on Marsh Creek
Quinte Sanitation	O	1970	14.5	36,400	18	52	29 non-hazardous industrial 1 tires, brush, metal	265 - stream	2,000	leachate plume, surface evidence
Sidney	C	1973	2.4	7,500	15	58	20 industrial 2 liquid 5 agricultural	200 - Potter Creek	2,800	N.I.
Stirling	O	N.I.	5	1,400	24	73	3 non-hazardous solid industrial	850 - Raudon	16,000	N.I.
Tricil Limited	O	1954	20	N.I.	N.I.	N.I.	accepted gasoline and oil - contaminated soil	0 - Marysville Creek	15,000	groundwater and surface evidence
ThurLOW a	C	N.I.	19.4	N.I.		85	15 industrial	500 - Moira River	8,000	N.I.
ThurLOW b	O	1972	15	3,470	14	70	14 non-hazardous 2 other	500 - Moira River	13,000	N.I.
Tyendinaga Reserve	O	N.I.	0.2	N.I.	N.I.	N.I.	machinery, drums, fule tanks	75 - Bay of Quinte	75	N.I.
Zebedee Containers	O	1970	2.8	18,250	20		80 non-hazardous industrial	150 - Jones Creek	3,000	groundwater plume

N.I. - no information

Table 10. Shoreline landfill sites in the Bay of Quite area (from Beak 1989a).

Site	Status (Open, Closed)	Years in Operation	Area (ha)	Disposal Rate (tonnes/a)	Waste Types (%)		
					Commercial	Domestic	Other
Trenton	C	1955-1971	14	9,385	30	58	10(1) 2(2)
Zwick's Island	C	1949-1971	14.2	N.I.	N.I.	N.I.	N.I.

1 - solid industrial

2 - liquid industrial

N.I. - no information

Table 11. Industrial waste disposal sites in the Bay of Quinte area (from Beak 1989a).

Site	Status (Open, Closed)	Start-up Date	Waste Types	Disposal Practise
Deloro Stellite	C	1962	spent foundry wastes - sand, cores, refractories, glass; packaging materials, drums	landfill in old lagoon
Domtar Packaging	O	1978	wood and paper waste black liquor sludge	landfill clay-lined and bermed lagoon
Bakelite Thermosets	C	1950	formaldehyde, hexamethyl- enetetramin, solid and liquid resins, moulding materials, micronized resins, plant wastes, construction debris, epichlorhydrin, polyethylene, pellets	burning and land- filling along swampy shoreline
Ontario Hydro	O	1971	sand, carbon sludge, rubble	landfill

N.I. - no information

Bakelite Thermosets Limited disposed of a number of chemical wastes on its property. Four surface water samples collected in 1972 from ponds and streams on the site revealed no chemical evidence of leachate impact. This site was reassessed by the Groundwater Unit, Ministry of the Environment - Southeastern Region in 1989. Results of this work are outstanding.

Ontario Hydro currently disposes of sand, carbon sludge and rubble at a rate of about 10 tonnes/year. The leachate concern depends on the chemical character of the carbon sludge (Beak 1989a).

2.6 WATER RESOURCE USE

2.6.1 Water Supply

The Bay of Quinte provides domestic and industrial water for the City of Belleville and the Towns of Deseronto and Picton. The Town of Trenton obtains its raw water from the Mayhew Creek watershed and the Trent River, and a distribution system from Lake Ontario supplies the Town of Napanee and the Township of Richmond. The rated capacities and average consumption volumes for the five water treatment plants are shown in Table 12.

Other water supply uses of importance including private domestic supplies for seasonal and permanent shoreline residential development, and crop, lawn and garden irrigation.

2.6.2 Commercial Fishing

Commercial fishing in the Bay of Quinte dates from colonial time, with initial records of catches starting in the early 1900s (Christie 1972). Between 1925 and the present, the average annual catches for all species ranged between about 300,000 kg and 600,000 kg (Hurley and Christie 1977; Hurley and Dentry 1984). Prior to 1983, gillnets and hoop nets were used; however, today, only impounding gear is permitted above Glenora. Stocks are managed by quotas which are set with a view to maintaining or restoring stocks for subsequent years.

The composition of the catch has changed over the years as stocks were depleted and as economic factors dictated. For example, in earlier years, the species of prime importance included: lake herring, lake whitefish, walleye, northern pike, yellow perch, white perch, bullheads and catfish, American eel, carp, and sunfish. However, beginning in the mid-1940s and continuing through to the mid 1960s, there was a shift in emphasis to stocks

Table 12. Rated capacities and average consumption volumes for water treatment plants servicing urban areas on the Bay of Quinte. All data are reproduced from Canviro (1988).

Source		Rated capacity (m ³ /day)	Average Consumption volumes (m ³ /day)
Trenton	Trent River	22,700	15,900
Belleville	Bay of Quinte	54,500	25,700
Deseronto	Bay of Quinte	3,000	1,200
Napanee ^a	Lake Ontario	12,700	6,400
Picton	Picton Bay	9,100	3,400

^a -the primary raw water source is Lake Ontario, although the Napanee River is used for emergencies.

of smaller individual size and less value per unit weight; the species mainly consisted of yellow perch, white perch, bullheads, catfish, sunfish, American eel and carp. The loss of prime fish species was caused by a number of factors including increased nutrient enrichment, the invasion of non-native fish species and high levels of exploitation. As well, high contaminant levels in the flesh of some species restricted harvests.

2.6.3 Sports Fishing

Walleye fishing was bountiful in the Bay of Quinte in the 1950s. In 1958, 105,200 angler hours yielded 13,300 kg, with about 50% of the harvest originating from Hay Bay. However, the stock persisted for less than a decade, collapsing after the 1959 year class.

Following the sudden emergence of an extensive walleye year class in 1978, a large sport fishery again appeared. Fisheries of eastern Lake Ontario, the St. Lawrence River and the Bay of Quinte now provide in excess of 250,000 angling days of activity per year, with 75% of the effort directed at the Bay of Quinte walleye fishery. Angling is estimated to be growing at a rate of about 12% per year. The Bay of Quinte Travel Association and Ontario Ministry of Tourism and Recreation estimated that approximately \$30 to \$45 million was spent on tourism within the Bay of Quinte area in 1984. The sports fishery was estimated to have contributed between \$1.3 and \$5.8 million to the regional economy in that year (Martin 1985; Trushinski 1986), and the bay has been described as "...an area which may have the best walleye fishery in North America." (Angler and Hunter, May 1988).

Estimates of angler effort and harvest of the individual creel seasons between 1981 and 1987 indicate that the 1987 fishery has grown relative to previous years (Tables 13 and 14). More specifically, the 1987 estimates for effort and harvest for the opening weekend fishery have almost doubled in comparison to levels in previous years. Data from Tables 13 and 14 were used to extrapolate and estimate angler effort and harvest for the whole open water season (Figure 7). As indicated, effort continued to grow; however,

Table 13. Estimated angling effort (rod hours) in the Bay of Quinte summer fishery, 1981 to 1987. Estimates are given for each creel season including the opening weekend (when data are available). All data are from Mathers (1988).

Angler effort (rod hours)							
Creel Season	1981	1982	1983	1984	1985	1986	1987
Opening	-	-	-	47237	43959	49593	90113
May ^a	97119	144163	-	180511 ^e	162162	253340	290225
June	62336	57126	-	-	58093	51949	81203
July	68401	71201	-	96607 ^b	94711 ^b	83075	82346 ^d
Aug.	58505	70898	-	83127 ^b	81495 ^b	101738	137428 ^b
Sept.	19426	25307	-	26960 ^b	26431 ^b	36635 ^b	44571 ^b
Oct.	9207	7572	-	13480 ^b	13215 ^b	18317 ^b	22286 ^b
Nov.	4704	6039 ^b	-	6740 ^b	6608 ^b	9159 ^b	11143 ^b
Dec.	0 ^c	0 ^c	-	0 ^c	0 ^c	0 ^c	0 ^c
Totals	319401	382306	-	451581	442717	554213	669202

a May data include the opening weekend data.

b Estimate based on current year's May and June total and the trend through season from 1981.

c Fishing effort in December remains unquantified but is considered negligible.

d The July 1987 estimate is extrapolated from data from July 1 to July 15, 1987.

e Separate May to June estimates for 1984 are not available.

Table 14 Estimated walleye harvest (number of fish) in the Bay of Quinte summer fishery, 1981 to 1987. Estimates are given for each creel season including the opening weekend (when data are available). All data are from Mathers (1988).

Walleye harvest (#'s)							
Creel season	1981	1982	1983	1984	1985	1986	1987
Opening	-	-	-	5527	11009	8507	17240
May ^a	56454	50232	-	55777 ^e	65917	80962	75230
June	38096	8289	-	-	3793	5877	6617
July	40428	16308	-	24522 ^b	27884 ^b	15027	6332 ^d
Aug.	19091	11743	-	11035 ^b	12548 ^b	18659	14732 ^b
Sept.	2669	1381	-	1839 ^b	2091 ^b	2605 ^b	2455 ^b
Oct.	3606	1059	-	2452 ^b	2788 ^b	3474 ^b	3274 ^b
Nov.	1796	1170 ^b	-	1226 ^b	1394 ^b	1737 ^b	1637 ^b
Dec.	0 ^c	0 ^c	-	0 ^c	0 ^c	0 ^c	0 ^c
Totals	162140	90182	-	102379	116415	128341	110277

a May data include the opening weekend data.

b Estimate based on current year's May and June total and the trend through season from 1981.

c Fishing effort in December remains unquantified but is considered negligible.

d The July 1987 estimate is extrapolated from data from July 1 to July 15, 1987.

c Separate May and June estimates for 1984 are not available.

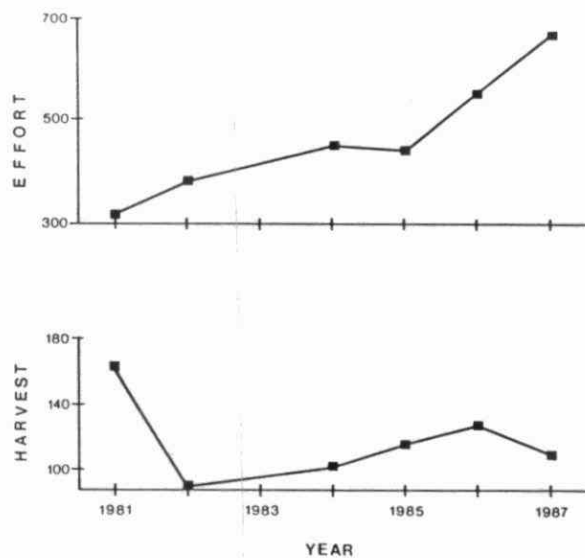


Figure 7. Trends in the Bay of Quinte sport fishery during the entire open water season. Shown are estimates of angler effort (in 1,000's of angler hours) and walleye harvest (in 1,000's of fish) (from Mathers 1987).

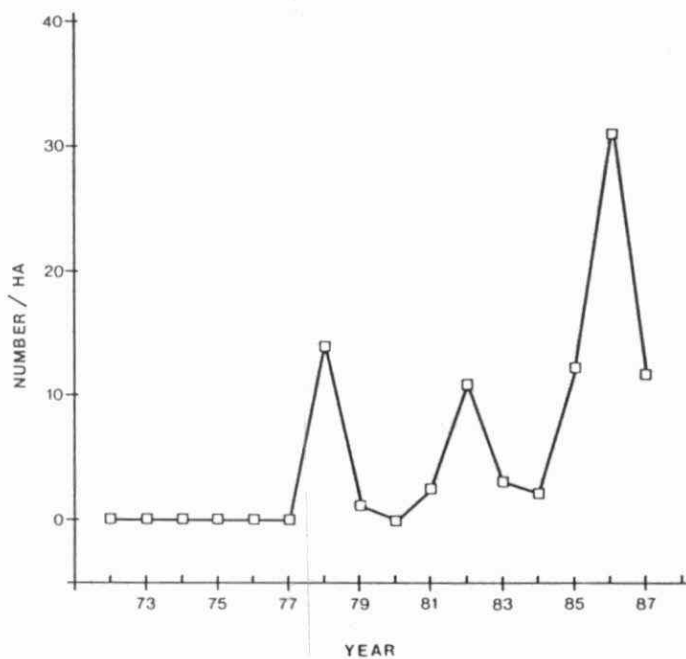


Figure 8. Estimates of density of young-of-the-year walleye in the Bay of Quinte from bottom trawls. The estimates are means for Big Bay, Hay Bay, and the Adolphus Reach during May to October (from Bowlby and Mathers 1987)

the 1987 harvest was down slightly from 1986. This decline appeared to be related to the relatively poor 1983 and 1984 year classes of walleye. However, even with the decline in harvest, the average catch per unit effort (CUE) has been 0.27. According to fisheries managers of the Ministry of Natural Resources, a walleye fishery capable of sustaining a CUE of 0.3 fish/angler hour and greater is considered to be a good fishery (A. Mathers 1988). While some anglers might consider a CUE of 0.3 fish/angler hour to be a poor quality fishery, the 0.3 value represents an average value for all anglers including those who are well-experienced and efficient and those who are less qualified and less knowledgeable. Accordingly, some Bay of Quinte anglers will have a very high quality experience (i.e., a CUE which exceeds one fish/angler hour) while others will experience a much lower quality standard (i.e., a CUE which is less than one fish/10 angler hours).

Long term estimates of densities of young-of-the-year (i.e., YOY) walleye have indicated that the 1985, 1986 and 1987 year classes were relatively strong (Figure 8). When these are recruited into the creel, fisheries managers predict that harvests should return to their higher levels. Accordingly, an exceptional walleye fishery appears certain for the Bay of Quinte, at least in the near future.

Current regulations for walleye include a possession limit of four and a closed fishery between March 1 and the first Saturday in May, which is the earliest opening for this species in Ontario. Northern pike, largemouth and smallmouth bass also provide a small but important component of the sports catch. Fishing for northern pike is not permitted between April 1 and the first Saturday in May; the legal limit is six fish in possession. Angling for largemouth bass and smallmouth bass is permitted between the last Saturday in June and November 30, with a possession limit of six.

2.6.4 Swimming and Boating

Considering its large surface area, many miles of shoreline and proximity to

several urban centres, the Bay of Quinte offers relatively few public swimming facilities. Small public beaches exist at Trenton, Belleville (Zwick's Island), Deseronto (Centennial Park), and Adolphustown Park. There does not appear to be an immediate need for establishing new beach facilities because of the 2,400 m of beach at Sandbanks Provincial Park, south of the Bay of Quinte on Lake Ontario. However, the Ministry of Natural Resources, Napanee District, believes that additional physical resources will be needed in future to meet increasing demands for swimming.

Boaters using the Bay of Quinte can access the Trent-Severn Waterway, which is part of the Trent-Severn-Rideau inland system, a navigational corridor of national importance. During the 1988 boating season, about 33,000 vessel movements occurred through the locks in the southern waterway (Parks Canada, personal communication); however, it is not known how many of these boaters originated or terminated their journey in the Bay of Quinte. Conversations with the Belleville District Chamber of Commerce revealed that boating activities have increased in recent years and have become a major recreational activity in the area. Increased boat traffic has enhanced the demand for marina facilities and good water quality.

2.6.5 Other Recreational Uses

There are a number of other summer and winter recreational uses which are provided by the bay; however, very little is known about their extent and economics. Such uses would include waterskiing, windsurfing, skating, ice-boating, cross-country skiing, snowmobiling, hunting, trapping, picnicking, hiking, and nature appreciation.

2.6.6 Fish and Wildlife Habitat

Fish and wildlife habitat exists around the shoreline of the Bay of Quinte as extensive areas of submergent and emergent plant species alternating with bare rocky shores. As noted earlier, existing wetland communities are uniformly distributed, although some large complexes occur in Muscote Bay, Hungry Bay and Hay Bay. Most wetlands throughout the bay are important for

waterfowl resting, production and staging, and fish spawning and nursing. Other resources within the various wetlands include wild rice, bullfrogs, snapping turtles and furbearers such as muskrats, racoons, mink, coyote, red foxes, etc. In terms of recreation, the complexes provide fishing, hunting, boating, trapping and nature appreciation opportunities.

Some species such as walleye confine their spawning activities to localized areas. In this regard, three sanctuaries have been established; one on the Moira River; another is on the Napanee River; the third is on the Trent River. The sanctuary on the Moira River has an extended status, which means that fishing is closed one week longer than in the other two.

No walleye spawning shoals have been identified nor priorities set for these shoals along the shoreline of the Bay of Quinte.

Spring and fall waterfowl surveys were undertaken in 1976/77 and 1988 by the Canadian Wildlife Service (Ross 1989) along the northeastern shore of Lake Ontario and the Ontario shoreline of the St. Lawrence River. The surveys were conducted in order to determine waterfowl distribution patterns, identify shifts in shoreline use over time, and attempt to provide possible reasons for changes in use by waterfowl. Two of the survey zones (Belleville and Picton) covered the Bay of Quinte; waterfowl characteristics for these zones are presented in Table 15 and are described by Ross (1989) as follows:

"The Quinte zones showed relatively minor changes in the spring use except for bay ducks which dropped in numbers; however, as the ice on the bay broke up later than during the earlier survey, availability of the zones to spring migrants was reduced. Fall use in both zones showed substantial increases in most categories, and in particular mergansers. It is suspected that the low level of waterfowl use noted in 1976 related to deteriorating habitat quality due to phosphorus pollution. Recent shifts in the fish community towards the larger species may well provide improved feeding opportunities for piscivorous waterfowl."

Overall, Ross (1989) noted that some changes recorded for the various waterfowl survey zones could be associated with alterations in habitat or hunting; however, they may simply reflect re-distribution of birds to other

Table 15. Quantity of waterfowl use (1,000's of waterfowl days) in the Belleville and Picton survey zones during spring and fall of 1976-7 and 1986 (from Ross 1989).

		Geese	Large dabblers	Small dabblers	Bay ducks	Golden- eyes	Sea ducks	Mergansers	Total
<u>Belleville</u>									
Spring	1976-7	0.8	2.4	0.4	4.1	2.6	Trace	39.3	49.8
	1986	2.3	1.9	0.8	6.4	7.2	0	28.7	47.2
Fall	1976-7	Trace	0.2	0.5	Trace	Trace	Trace	Trace	0.8
	1986	11.7	13.3	0.9	11.2	5.4	0	60.0	102.6
<u>Picton</u>									
Spring	1976-7	0.9	0.2	Trace	90.7	18.2	0.3	18.5	129.0
	1986	6.2	0.7	0	46.3	7.5	0.2	12.9	73.9
Fall	1976-7	Trace	2.3	0.8	1.0	7.0	Trace	3.4	14.6
	1986	Trace	11.3	0.8	0.9	21.6	6.8	14.1	55.5

areas due to shifts in migration routes, rather than actual population changes. Confirmation of these aspects requires further research.

In recent years, considerable work has been undertaken to set priorities for the bay's emergent wetland communities. Maltby et al. (1983) included three shoreline marshes in the Bay of Quinte as part of a group of 35 southern Ontario wetlands. The overall evaluation, based partly on recreational values and amenities, ranked Hay Bay as a wetland of high significance and Big Island Marsh and Muscote Bay as moderately significant.

As well, the Ministry of Natural Resources has designated four Bay of Quinte wetlands as provincially significant:

- . the Sawguin Creek Marsh in Ameliasburgh Township south of Belleville, (surface area - 1,956 ha) is a Class II wetland;
- . the Lower Napanee River Marsh in Richmond and North Fredericksburgh Townships (surface area - 187 ha) is a class II wetland;
- . the Hay Bay Marsh in North and South Fredericksburgh Townships (surface area - 970 ha) is a class I wetland; and
- . the Fish Lake Wetland in Sophiasburg Township (surface area - 467 ha) is a class II wetland.

A fifth wetland (Cressy Swamp, surface area - 104 ha) is currently being evaluated. It is the Ministry of Natural Resources's intent - via a provincial policy - to protect all Class I and II wetlands in southern Ontario. Moreover, the proposed policy will provide direction to local and regional municipalities to identify and protect Class III to VII wetlands at their discretions (for example, Big Island Marsh which is a Class III wetland).

2.6.7 Waste Disposal

Treated municipal and industrial wastes are discharged to the Bay of Quinte at Trenton, Belleville, Deseronto, Napanee, Picton, Prince Edward Heights, and Canadian Forces Base (CFB) Trenton (Figure 6). The long term average daily discharge from all of the sewage treatment plants (STP) is $66,130 \text{ m}^3$ (Canviro Consultants 1987). Total loadings of BOD_5 , suspended solids, and total phosphorus to the Bay of Quinte are summarized in Appendix D. Based on 1986 performance data, the Deseronto STP met all compliance requirements for BOD_5 , suspended solids and total phosphorus for every month. Trenton and Picton met their BOD_5 and suspended solids requirements; however, on occasion, the 0.5 mg/L total phosphorus requirement was exceeded. At Belleville, the 0.5 mg/L requirement for total phosphorus and the 25 mg/L BOD_5 limit were periodically exceeded. Napanee and Prince Edward Heights experienced problems throughout 1986 meeting suspended solids and total phosphorus requirements, while the data provided from Trenton's CFB STP was inaccurate and suspect of error.

While some of the upstream STPs (i.e., Hastings, Marmora, Frankford and Batawa) are currently providing phosphorus removal down to 0.5 mg/L , others are not. For example, the Peterborough and Campbellford systems are treating to a discharge concentration of 1.0 mg/L .

There are no major industries discharging wastes directly to the bay. Domtar Wood Preserving, Domtar Packaging, and Trent Valley Paperboard Mills all have treated wastes which discharge to the Trent River near its mouth. Corby Distilleries discharges its treated wastes into the Moira River a considerable distance upstream of the bay. Strathcona Papers discharges wastes into the Napanee River. Bakelite Thermosets Limited at Belleville is situated on the bay east of Belleville; its process wastes are directed to the municipal STP, while cooling water from the plant processes and phenolic wastes from contaminated soils drain to the bay.

Water treatment plants at Trenton, Belleville, Deseronto, Napanee, and Picton discharge an estimated total annual loading of 313 kg/yr BOD₅, 18,315 kg/yr suspended solids and 40 kg/yr total phosphorus (see Appendix E). The sources are filter and microstrainer backwash and settling tank sludge.

3. EXISTING ENVIRONMENTAL CONDITIONS



3.1 WATER - PHYSICAL AND CHEMICAL

3.1.1 Morphometry and Hydrology

The Bay of Quinte varies morphometrically; large, shallow expanses occur in the upper bay while fjord-like troughs are common to the lower bay (Minns et al. 1986). The hypsometric curves shown in Figure 9 for the three bays show this considerable variation. Information on surface areas, mean and maximum depths and volumes are also presented in Figure 9.

River flows dominate the water budget of the Bay of Quinte (Figure 10), and pronounced seasonal differences occur. The lowest flows occur during the summer, while the highest flows usually occur during the March to April period. Annually, the whole bay flushes between 2.0 and 3.2 times, but during the low flow summer period, flushing is reduced to 0.25 to 1.03 times. Flushing times also vary considerably between the bay segments, with the middle bay flushing times the most dynamic (Minns et al. 1986). Low, mean, and high annual and summer runoff volumes for the five major tributaries draining to the Bay of Quinte are presented in Table 16 (low and high flows were calculated from the mean $\pm$ two standard deviations). Flushing rates are shown in Table 17.

The backflow of water from Lake Ontario via the Upper and Lower Gaps also affects water quality in the middle and lower bays (Figure 11), while the upper bay is not influenced to any degree by backflowing Lake Ontario water. These backflows have low-nutrient concentrations; accordingly, any responses to reduced phosphorus loadings (e.g., at local municipal sewage treatment plants) will most readily be observed only in the upper bay.

3.1.2 Water Temperature and Dissolved Oxygen

The increase in water depths from the shallow upper bay (mean depth of

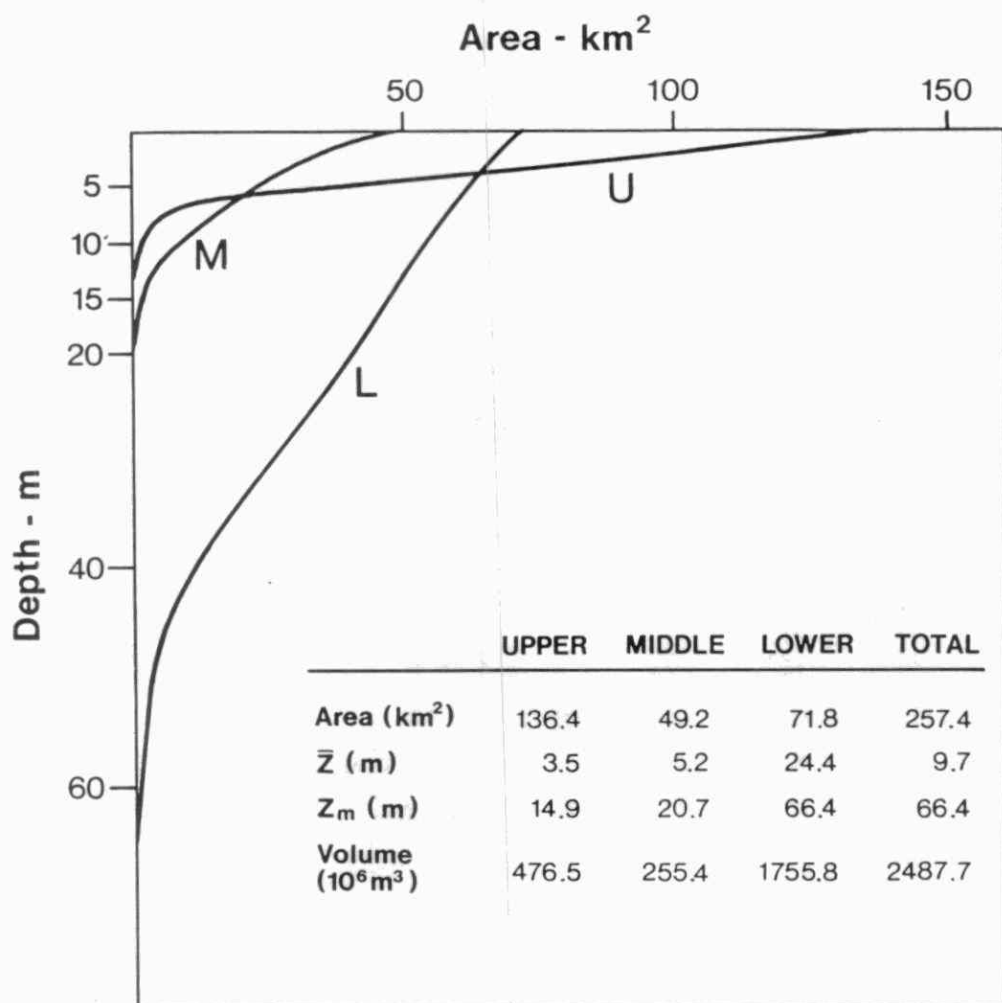


Figure 9. Hypsometric curves for the three bay sections and associated morphometric data (from Minns et al. 1986).

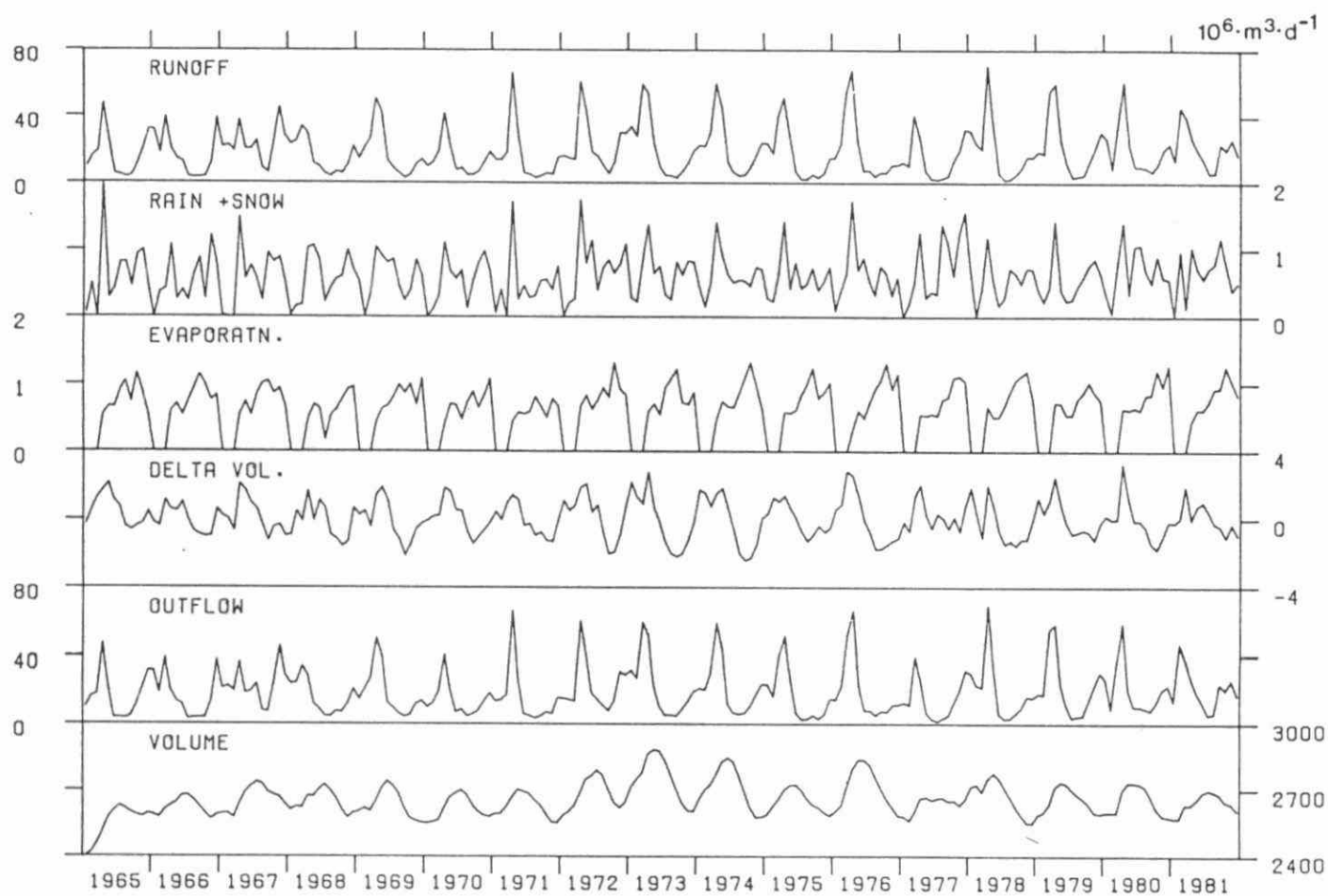


Figure 10. Monthly water budget of the Bay of Quinte by component, 1965-1981 (from Minns et al. 1986).

Table 16. Estimated low, mean, and high annual summer flows (m^3/sec).
Lows and highs were calculated from the mean $\pm$ two standard
deviations from the mean (from Minns 1986).

River	Annual			Summer		
	Low	Mean	High	Low	Mean	High
Trent	81.5	132.6	215.5	28.5	61.0	130.7
Moira	17.5	30.0	51.4	2.5	8.3	27.7
Salmon	5.9	10.4	18.3	0.5	2.4	11.2
Napanee	5.2	9.0	15.7	0.7	2.3	7.4
Wilton	0.8	1.4	2.4	0.1	0.2	0.8
Total	117.4	194.9	323.9	32.7	76.1	184.8

Table 17. Whole-bay and sectional flushing rates, uncorrected and corrected for back-flows from Lake Ontario. Flushing rates are expressed as times per year and times per summer (May to September, inclusive). All data are from Minns et al. 1986.

Year	Uncorrected				Corrected		
	Upper	Middle	Lower	Whole	Middle	Lower	Whole
Annual							
1965	11.9	22.4	3.3	2.3	-	-	-
1966	11.0	21.7	3.4	2.3	-	-	-
1967	14.6	29.1	4.7	3.2	84.2	16.4	11.6
1968	9.9	20.1	3.2	2.2	50.1	8.5	6.0
1969	11.4	22.9	3.7	2.5	99.0	8.4	5.9
1970	9.2	18.2	2.9	2.0	-	-	-
1971	9.8	19.6	3.1	2.1	-	-	-
1972	13.9	28.1	4.6	3.1	219.5	9.5	6.7
1973	12.3	25.4	4.3	2.8	346.8	11.5	8.1
1974	12.8	26.0	4.3	2.9	81.6	12.9	9.1
1975	10.3	20.9	3.4	2.3	97.4	9.2	6.5
1976	11.6	23.7	3.9	2.6	54.0	9.6	6.8
1977	9.2	18.5	2.9	2.0	131.4	7.7	5.4
1978	11.8	23.9	3.9	2.6	55.6	19.6	13.8
1979	13.8	27.8	4.4	3.0	312.4	16.7	11.8
1980	12.9	25.9	4.1	2.8	236.6	15.8	11.2
1981	13.1	25.5	4.0	2.7	101.5	16.5	11.6
Summer							
1965	2.8	4.36	0.66	0.45	-	-	-
1966	1.94	3.82	0.61	0.41	-	-	-
1967	4.03	8.04	1.31	0.88	16.41	4.02	2.84
1968	1.89	3.94	0.65	0.44	6.81	4.58	3.23
1969	3.71	7.54	1.25	0.84	18.90	4.46	3.15
1970	2.49	4.97	0.80	0.54	-	-	-
1971	2.42	4.86	0.79	0.54	-	-	-
1972	4.59	9.39	1.58	1.05	19.18	4.20	2.96
1973	2.11	4.47	0.80	0.52	23.14	3.58	2.53
1974	3.47	7.22	1.26	0.83	20.63	6.16	4.35
1975	2.28	4.62	0.77	0.51	21.42	3.81	2.67
1976	2.36	4.93	0.86	0.57	19.62	5.63	3.97
1977	0.98	2.02	0.33	0.23	12.16	2.11	1.49
1978	2.47	5.09	0.87	0.58	15.00	6.36	4.49
1979	2.42	4.95	0.82	0.55	22.48	7.17	5.06
1980	2.95	6.10	1.02	0.68	22.32	6.87	4.85
1981	3.33	6.58	1.06	0.72	19.36	5.17	3.65

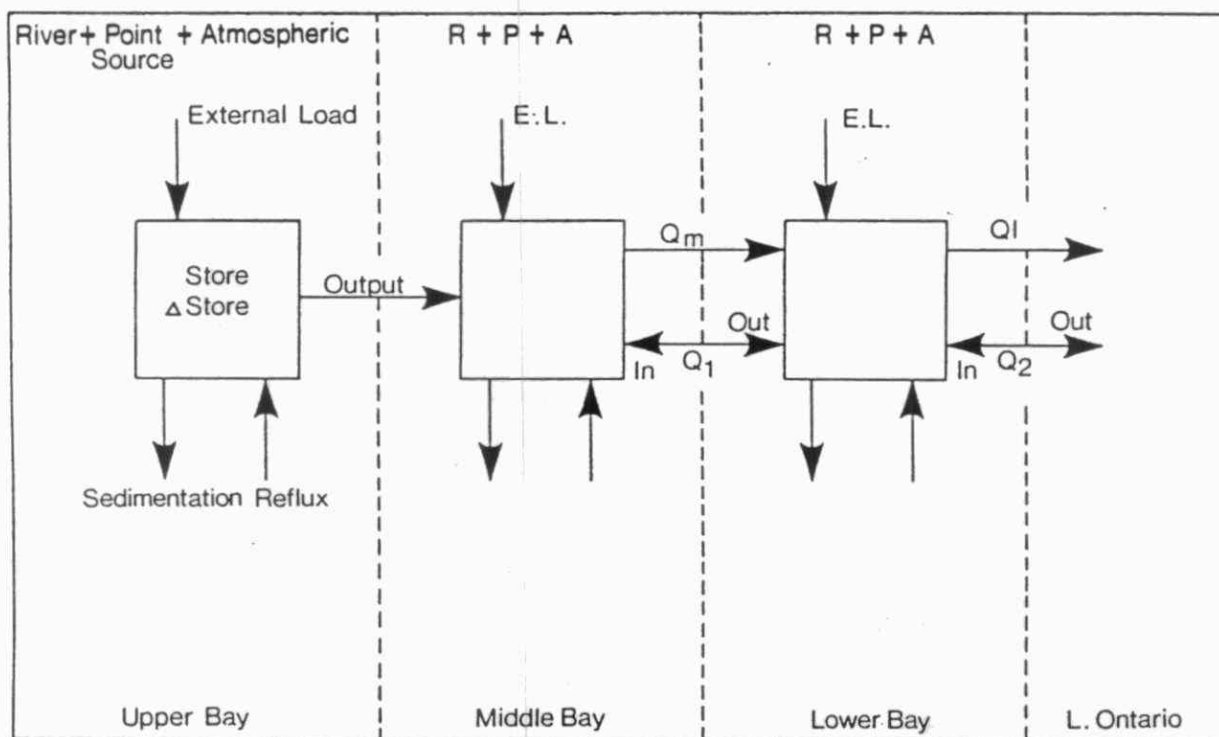


Figure 11. Conceptual model of sectional budgets for the Bay of Quinte (from Minns et al. 1986).

3.5 m), to the much deeper lower bay (30 m at Conway), contributes to the marked temperature gradient, and hence, physical-chemical quality between sections of the bay.

In mid-summer, the upper bay is generally well-mixed by wind, and water temperatures usually exceed 20°C from surface to bottom. Dissolved oxygen levels are usually similar at all depths, except during periods of temporary summer stratification when concentrations are sometimes reduced to as low as 3.8 mg/L. A value of 5.0 mg/L is considered adequate for warm water species of fish. Supersaturated conditions occur frequently in all three bays, and occasionally, the entire water column is supersaturated with oxygen (Robinson 1986).

In the middle bay, which has a mean depth of 5.2 m, distinct thermoclines frequently develop, with temperature differences of up to 10°C between surface and bottom. However, the rate of warming of the bottom waters is about 1°C/week, over the April to September period, so that by the end of the summer, the water column is near homothermous in most years. Surface water temperatures often lag behind those of the upper bay and maximum readings sometimes do not occur until mid-August. Lower dissolved oxygen levels (i.e., minimum of 0.6 mg/L in Hay Bay in August, 1980), are usually recorded in or below the thermocline or at mid-depth. Supersaturated oxygen conditions frequently develop in the upper strata of the middle bay, and occasionally extended to the thermocline or bottom.

As reported by Robinson (1986), the lower bay stratifies during the summer months; but, even at its deepest point (60 m) the temperature gradient between surface and bottom is gradual. Maximum surface water temperatures do not materialize until August, and are never as high as in the upper and middle bays. Again, supersaturated oxygen conditions frequently develop in the upper waters, sometimes extending to the bottom of the bay, especially in the early part of the year. In the deeper waters, dissolved oxygen gradually diminishes over the summer months, indicating that there is little or no

vertical mixing of near-bottom waters. Levels as low as 1.3 mg/L were reported near Glenora in late August of 1980; such low concentrations are unsatisfactory for both warm and cold water fish. In some years, oxygen levels were lowest at intermediate depths (i.e., about 20 m).

Minns and Johnson (1986) calculated that deep water oxygen depletion rates in the lower part of the Bay of Quinte should diminish with decreasing phosphorus loadings. Yet, conditions in Adolphus Reach did not improve following implementation of phosphorus controls in 1978 (Robinson 1986). It is obvious the results of time-series analyses of oxygen depletion rates under changing nutrient regimes differ from empirical predictions. As argued by Minns and Johnson (1986), "...the discrepancy is likely due to lags in the response of lakes to changing nutrient inputs. In time-series studies, time must be allowed before a new steady state is established. The lag is due to sediment oxygen demand which is related to the enrichment of the sediments and internal nutrient loading. Our new hypothesis for the Bay of Quinte is that oxygen depletion rates will not decrease until internal nutrient loading decreases." In effect, the Bay of Quinte will require a lengthy recovery period once artificial sources of phosphorus have been reduced. This lag results from phosphorus pools in the sediments which continue to load overlying waters for a time until a new steady state is reached. The fact that oxygen depletion rates have not diminished yet in Adolphus Reach reflects this lag.

3.1.3 Vertical Light Extinction

Light measurements have been taken in the Bay of Quinte during the May-October periods since 1972. During the pre-phosphorus control period, vertical light extinction (E_{par}) values were lowest in the upper bay during May (0.7-0.8/m). Marked increases occurred during the summer, with values sometimes exceeding 3.0/m. Transparency was greatest in the lower bay; E_{par} values ranged between 0.4/m and 0.8/m, with no distinct seasonal trends (Millard and Johnson 1986).

There were substantial decreases in vertical light extinction values immediately following 1977 in the upper bay, compared with the pre-1977 period; however, by 1985, E_{par} values had again increased (Table 18). In both the lower bay and middle bay, no recent trends to higher E_{par} values were evident (Table 18). In 1986 in the upper bay, the seasonal mean and maximum light extinction coefficients were the lowest of the entire study at 1.18/m and 0.79/m respectively. Record low values for light extinction coefficients were also noted in the middle bay. In the lower bay, light extinction remained unchanged relative to previous years; in this regard, the 1980 seasonal mean and maximum of 0.54/m and 0.79/m were remarkably close to the means for these parameters (i.e., 0.57/m and 0.86/m) over the entire post-phosphorus control period, 1978-1987.

3.1.4 Water Clarity

Water clarity may be influenced by phytoplankton, or suspended particulate material (i.e., clay and colloidal material washed in from the watershed) together with humic substances (resulting mainly from dissolved organic compounds present in the watershed).

Secchi disc measurements are good indications of water clarity. Mean summer Secchi disc values in the upper, middle, and lower bays of the Bay of Quinte are presented in Table 19. A gradient in water clarity was present between the upper bay and lower bay, although between the upper and middle bays, differences were not as apparent. On the basis of Secchi disc, water clarity in the upper bay has not improved substantially as a result of the phosphorus controls implemented in 1977. The mean post-phosphorus control Secchi disc measurement in the upper bay of 1.4 m was only 0.2 m greater than the mean pre-control value. Likewise, little improvement in water clarity has been measured in either the middle or lower bays.

3.1.5 Alkalinity, Conductivity and Chloride

Alkalinity is a measure of a system's carbonate-bicarbonate capacity to

Table 18. Seasonal means and maxima for the vertical light extinction coefficient (E_{par}) in the upper, middle and lower bays, 1972-1987. Pre-phosphorus and post-phosphorus control means are also provided.

Year	Upper Bay		Middle Bay		Lower Bay	
	Average	Maximum	Average	Maximum	Average	Maximum
1972	1.63	2.56	1.42	2.00	.64	1.10
1973	1.83	2.71	1.36	2.00	.64	.89
1974	2.02	3.18	1.43	2.63	.72	1.03
1975	1.96	3.07	1.44	2.05	.68	.99
1976	1.99	3.18	1.56	2.09	.61	.94
1977	1.82	3.07	1.39	2.22	.53	.76
Pre-phosphorus control						
Mean	1.88	2.96	1.43	2.17	.64	.95
1978	1.44	2.19	1.27	1.84	.53	.96
1979	1.52	2.97	1.37	2.71	.63	.94
1980	1.47	2.25	1.38	1.81	.66	.83
1981	1.39	1.92	1.33	2.30	.60	.87
1982	1.45	2.30	1.28	2.56	.55	.75
1983	1.33	1.84	1.27	1.75	.55	.86
1984	1.50	2.42	1.45	2.70	.55	1.03
1985	1.86	2.56	1.27	1.83	.54	.74
1986	1.18	1.33	1.12	1.53	.54	.79
1987	1.48	2.27	1.29	2.06	.56	.84
Post-phosphorus control						
Mean	1.48	2.27	1.29	2.06	.56	.84

Table 19. Minimum, maximum and mean Secchi disc values (m) for the upper, middle, and lower bays of the Bay of Quinte, 1972-1987. Means for pre-phosphorus control (1972-1977) and post-phosphorus control (1978-1987) are also provided.

Year	Upper Bay			Middle Bay			Lower Bay		
	Minimum	Maximum	Mean	Minimum	Maximum	Mean	Minimum	Maximum	Mean
1972	0.8	2.1	1.4	1.0	2.2	1.4	1.9	4.2	3.0
1973	0.8	2.1	1.2	1.0	2.4	1.6	2.2	3.7	2.8
1974	0.6	2.2	1.1	0.7	2.3	1.3	1.5	3.5	2.5
1975	0.6	2.0	1.0	0.8	1.7	1.1	1.6	4.0	2.5
1976	0.6	1.9	1.1	0.8	1.9	1.3	2.0	4.1	2.9
1977	0.7	2.0	1.3	1.0	2.6	1.6	2.7	4.8	2.6
1978	0.8	2.0	1.3	0.8	3.0	1.5	1.8	4.5	3.2
1979	0.6	2.2	1.3	0.6	2.2	1.4	1.6	4.0	2.5
1980	0.7	2.0	1.3	0.9	1.9	1.4	1.5	3.5	2.7
1981	0.9	2.4	1.4	1.0	2.0	1.3	1.8	3.5	2.7
1982	0.9	2.0	1.3	0.8	2.5	1.4	2.3	4.0	2.9
1983	0.8	3.4	1.6	0.9	2.5	1.5	1.8	4.0	3.0
1984	0.8	2.0	1.1	0.8	1.9	1.2	1.2	3.9	2.5
1985	0.8	1.9	1.2	0.9	2.0	1.4	2.2	5.2	3.4
1986	1.3	2.6	1.7	1.0	2.0	1.7	2.0	4.7	3.0
1987	0.8	2.5	1.7	1.0	2.5	1.7	2.5	4.5	3.0
Mean 1972-1977			1.2			1.4			2.7
Mean 1978-1987			1.4			1.4			2.9

buffer water against acidification. Surface waters vary considerably in their ability to neutralize acid loadings, with those in alkaline soils or limestone deposits having greater capability to neutralize acidic inputs than lakes and streams in Ontario's Precambrian Shield. Alkalinity values in the Bay of Quinte averaged 91-109 mg/L in the upper bay and decreased to 91-96 mg/L in the lower bay. Concentrations were similar at all depths. These values indicate that the bay has a substantial buffering capacity and is not sensitive to acidification.

Conductivity is a measure of the quantity of dissolved substances in water. The major contributing ions are calcium, magnesium, sodium, potassium, bicarbonate, sulphate and chloride. These ions are leached from rocks and soils in the watershed. In the Bay of Quinte conductivity readings gradually increase from about 220-270 umhos/cm in the upper bay to about 300 umhos/cm in the lower bay. The higher levels in the lower bay reflect incursions of water from Lake Ontario. In general, conductivities in the Bay of Quinte's watershed gradually increase downstream, for example, from Little and Big Bald Lakes (i.e., 153 umhos/cm) to Clear Lake (i.e., 173 umhos/cm) to Rice Lake (i.e., 200 umhos/cm), indicating the change in bedrock and related drainage characteristics (reproduced from Ontario Ministry of the Environment and Ontario Ministry of Natural Resources 1976).

Chloride can indicate local sources of pollution. The provincial drinking water guideline is 250 mg/L (i.e., maximum desirable concentration in relation to aesthetic quality). In the upper bay, chloride concentrations were relatively low (i.e., 5-11 mg/L) throughout the ice-free season. In the middle bay, concentrations were low in the spring and fall (i.e., 5-9 mg/L), but fluctuated during the summer months (i.e., 5-22 mg/L). Also, chloride values near the bottom were considerably higher (i.e., up to 30 mg/L) than at the surface, reflecting the influence of Lake Ontario water. In the lower bay, highest levels were similarly recorded near the bottom (i.e., 13-25 mg/L), again indicating Lake Ontario incursions. As indicated, all

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3.1.6 Total Phosphorus

Since measurements were made in 1960 a gradation in total phosphorus has existed between the upper and lower bays. The highest phosphorus levels occur in the upper bay (Table 20). Pre-phosphorus control concentrations ranged from 52 ug/L to 89 ug/L (seasonal mean) in the upper bay, from 37 ug/L to 63 ug/L in the middle bay, and from 18 ug/L to 38 ug/L in the lower bay (Robinson 1986). In general, nuisance concentrations of algae begin to develop when average concentrations during the summer months exceed 20 ug/L.

After the 1977 phosphorus reductions, total phosphorus concentrations diminished by about 40% in the upper bay, 20% in the middle bay, and essentially were unchanged in the lower bay (Table 20). Between 1986 and 1987, total phosphorus concentrations throughout the bay were the lowest on record. Relative to 1985, phosphorus concentrations in 1987 in the upper bay were down by 31%, in the middle bay by 30% and the lower bay by 19%. However, in 1988, concentrations increased in the upper bay to levels reported in the early 1980s.

In the upper bay and middle bay, prominent peaks occurred during late July to September in the pre-phosphorus removal period. After phosphorus loading controls were implemented, these summer maxima decreased.

Likewise, higher concentrations were found near the bottom than were measured in surface waters in August of most years prior to phosphorus removal. After phosphorus controls, concentrations in late summer exceeded euphotic zone levels less often (Robinson 1986).

Table 20. May to October average total phosphorus concentrations ($\mu\text{g/L}$) in the upper, middle and lower bays, 1972-1988. Pre-phosphorus control (1972-1977) and post-phosphorus control (1978-1988) means are also provided.

	Upper Bay			Middle Bay			Lower Bay		
	Minimum	Maximum	Mean	Minimum	Maximum	Mean	Minimum	Maximum	Mean
1972	31	120	70	29	111	63	6	82	23
1973	31	160	90	26	120	52	12	52	21
1974	25	180	79	27	111	50	14	75	24
1975	23	140	89	25	90	56	16	27	20
1976	22	116	70	14	90	45	14	38	20
1977	27	144	70	21	78	47	9	47	19
1978	21	86	48	16	82	40	7	24	18
1979	23	87	46	17	70	34	13	63	21
1980	23	106	47	25	68	38	13	62	23
1981	30	90	51	33	88	46	16	38	24
1982	28	250	50	22	100	46	10	27	19
1983	19	98	53	21	88	44	11	33	19
1984	28	100	54	28	66	46	10	26	17
1985	31	81	51	23	60	42	12	32	18
1986	21	44	31	21	62	35	8	22	14
1987	11	73	37	16	56	31	7	18	11
1988	24	71	49	18	52	33	8	32	16
<u>Mean</u>									
1972-77			78			51			21
1978-88			49			40			18

Soluble reactive phosphorus concentrations have averaged about 10%-15% of total phosphorus concentrations and reductions of about 30%-40% after 1977 were measured (Robinson 1986)

3.1.7 Nitrogen, N/P and Silica

Total nitrogen concentration was reduced by 13%-20% in the upper bay and 3%-4% in the middle bay although an increase of 3%-16% occurred in the lower bay immediately following point-source phosphorus loading controls (Robinson 1986). The overall decrease in total nitrogen was attributed to a relatively large reduction in total organic nitrogen, as measured by lower phytoplankton biomass (see Section 3.5). Prior to phosphorus loading controls, the upper bay and lower bay experienced inorganic nitrogen depletion (<0.005 mg/L). After 1978, nitrate concentrations were not reduced as severely, indicating under-utilization by phytoplankton.

The mean N/P ratios in the post-phosphorus control period have increased 20%-32% over the ratios in the pre-phosphorus control period (Table 21). The 1986 and 1987 ratios of total nitrogen to total phosphorus were greatly increased in the lower bay (i.e., +81%) and moderately in the upper bay (i.e., +28%) and middle bay (i.e., +22%) over 1985 ratios. The increased ratios for the upper bay and middle bay can be explained directly by the corresponding decreases in total phosphorus; whereas, the increase N/P in the lower bay is because of increases in total nitrogen rather than the decrease (i.e., 10%) in total phosphorus.

Silica has responded to phosphorus loading controls in much the same way as nitrate because ambient concentrations have been determined largely by the intensity of utilization by phytoplankton. However, in recent years, silica concentrations in the upper bay have returned to levels more typical of the pre-phosphorus control period (Figure 12). This trend relates to the recent observed increases in the diatom Melosira (Nicholls and Hurley 1989).

Table 21. Ratios of total nitrogen to total phosphorus in the upper, middle and lower bays, 1972-1988. Pre-phosphorus control (1972-1977) and post-phosphorus control (1978-1988) means are also provided.

	Upper Bay	Middle Bay	Lower Bay
1972	11.6	13.4	21.3
1973	10.4	16.6	21.3
1974	10.1	12.9	19.1
1975	9.7	12.7	20.2
1976	11.5	14.5	21.9
1977	12.6	15.6	23.8
1978	13.7	16.3	27.7
1979	14.5	18.4	24.0
1980	13.3	18.1	22.4
1981	14.8	17.3	23.4
1982	16.0	16.6	31.0
1983	12.8	15.1	25.4
1984	15.2	16.9	32.7
1985	16.9	18.0	27.6
1986	21.3	20.5	43.1
1987	21.9	23.5	56.8
1988	17.5	19.0	31.0
<u>Mean</u>			
1972-77	11.0	14.3	21.3
1978-85	16.1	18.1	31.3

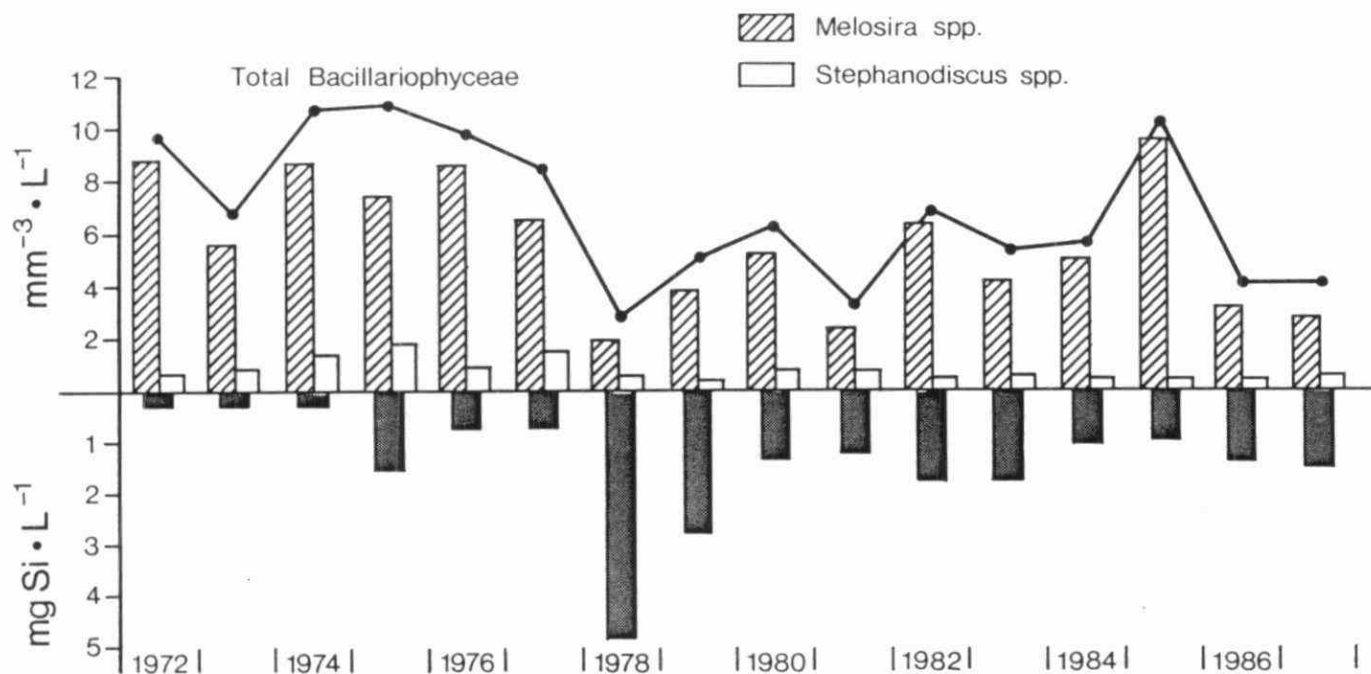


Figure 12. Total Bacillariophyceae (diatom) biomass and the two major generic components, *Melosira* and *Stephanodiscus* over the May-October periods of 1972-1986 in the upper Bay of Quinte. Also shown are dissolved silicate levels (mg/L) over the same time (from Nicholls and Hurley 1989).

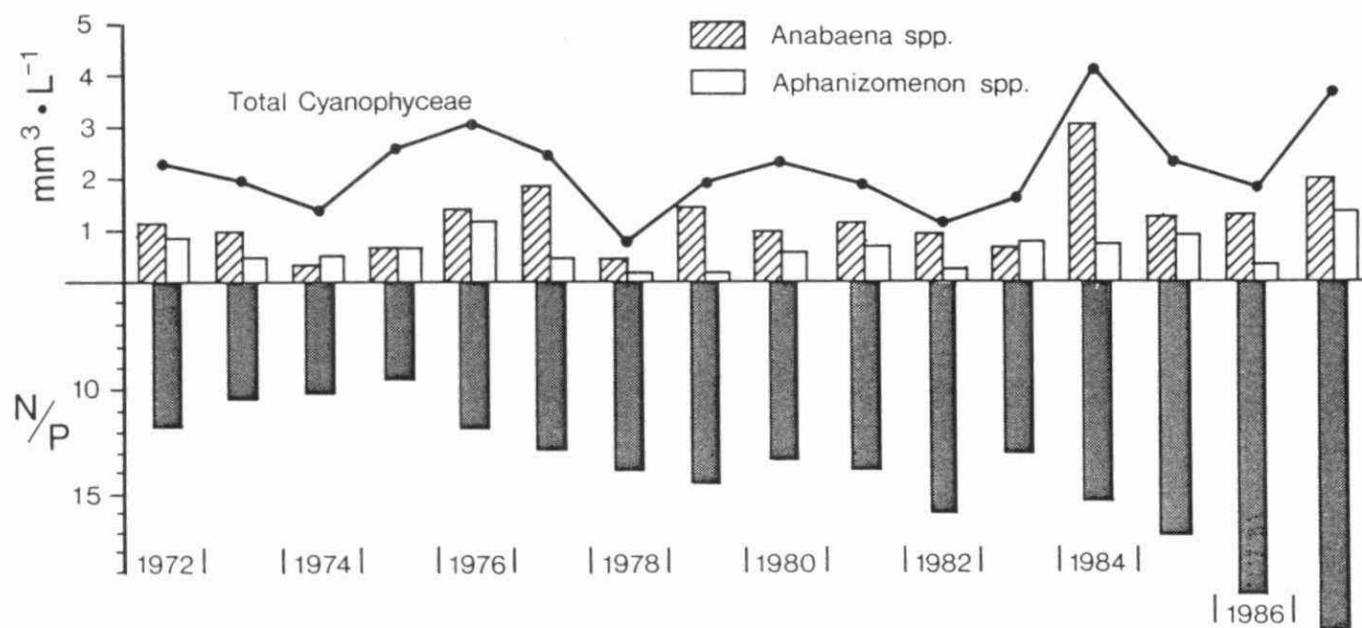


Figure 13. Total Cyanophyceae (blue-green algae) biomass and the two major generic components, *Anabaena* and *Aphanizomenon* over the May-October periods of 1972-1986 in the upper Bay of Quinte. Also shown are total nitrogen to total phosphorus ratios over the same time (from Nicholls and Hurley 1989).

3.1.8 Chlorophyll a

As reported by Robinson (1986), a chlorophyll a concentration gradient similar to that of total phosphorus existed throughout the Bay of Quinte. Prior to 1978, chlorophyll a concentrations ranged from 13.1 ug/L to 36.7 ug/L (seasonal mean) in the upper bay, from 12.9 ug/L to 23.6 ug/L in the middle bay, and from 5.9 ug/L to 12.6 ug/L in the lower bay. The introduction of phosphorus controls in 1977 resulted in an immediate reduction in chlorophyll a throughout the entire bay. The greatest decrease was in the upper bay where 42% reductions occurred. In the middle bay, concentrations were reduced by 17% and in the lower bay by 14% (Table 22).

3.1.9 Heavy Metals and Organic Contaminants

3.1.9.1 Historical perspectives

Historical data on persistent toxic contaminants in the Bay of Quinte was compiled and evaluated with regard to their environmental significance (Beak 1988). Assuming that protection of human health and aquatic life require contaminant concentrations to be below existing criteria for these uses (Table 23), some concerns were revealed.

- Iron was found in STP effluents at Trenton, Belleville, Napanee and Picton, and in site drainage from Bakelite Thermosets Limited. As well, the Ministry of the Environment's (MOE) water quality objective for the protection of aquatic life for iron (i.e., 300 ug/L) was exceeded in water samples taken from the Trent River below Number 1 Dam, the Moira River near its mouth, Demorestville Creek, the Salmon River, the Napanee River, the Sawguin River and Picton Marsh Creek.
- The MOE's water quality objective for the protection of aquatic life objective for copper (i.e., 5 ug/L) was exceeded in surface water samples from the Trent, Moira, Napanee and Sawguin rivers, and in the Millhaven,

Table 22. Minimum, maximum and mean chlorophyll a concentrations ($\mu\text{g/L}$) for the upper, middle, and lower bays of the Bay of Quinte, 1972-1987. Pre-phosphorus control (1972-1977) and post-phosphorus control (1978-1987) means are also provided. All data are taken from Project Quinte Chemical Limnology Data Report (1988), except the 1987 means which are reproduced from Project Quinte 1987 Annual Report (1988)

Year	Upper bay			Middle bay			Lower bay		
	Minimum	Maximum	Mean	Minimum	Maximum	Mean	Minimum	Maximum	Mean
1972	3.4	60.0	15.7	3.9	41.0	19.8	<1.0	32.0	9.0
1973	4.2	140.0	41.9	3.7	66.0	23.4	3.1	14.5	7.3
1974	5.6	66.0	21.5	5.8	36.0	15.6	2.8	13.0	5.9
1975	5.0	64.0	34.5	7.0	42.0	23.6	3.4	12.0	6.7
1976	5.8	56.0	24.9	8.3	48.0	20.6	3.5	20.0	7.8
1977	4.1	88.2	35.7	5.4	55.0	28.1	3.3	12.4	6.7
1978	0.6	29.3	12.5	2.4	33.6	13.3	1.8	13.2	4.8
1979	3.3	44.4	18.2	5.2	47.2	18.3	3.2	15.4	6.1
1980	5.1	33.0	15.0	4.2	34.0	17.8	2.7	10.0	6.3
1981	4.0	32.0	14.3	5.1	32.0	16.4	0.8	13.0	5.8
1982	3.5	40.2	15.7	2.0	45.5	19.1	2.1	10.5	5.4
1983	2.3	28.0	11.4	4.3	41.2	17.8	2.0	22.4	7.3
1984	2.8	36.4	15.6	2.1	42.0	20.2	3.0	28.4	8.0
1985	4.4	54.2	29.9	< 0.3	37.8	17.9	3.2	31.6	10.9
1986	7.1	25.8	11.2	< 0.6	41.5	19.8	3.5	13.1	6.4
1987	NA	NA	25.4	NA	NA	20.3	NA	NA	5.4
Mean 1972-1977			29.0			21.8			7.2
Mean 1978-1987			16.9			18.0			6.6

Table 23. Criteria for evaluation of water, sediment and fish quality (from Beak 1988b).

Chemical Parameter	Treated Drinking Water (ug/L)		Aquatic life (ug/L)		Fish consumption (mg/kg)		Dredge disposal (ug/g)		Sediment background (ug/g)
Cadmium	5	MOE	0.2	MOE			1	MOE*	3.7
Chromium	50	MOE	100	MOE			25	MOE*	86
Copper	1,000	MOE	5	MOE			25	MOE*	100
Iron	300	MOE	300	MOE			10,000	MOE*	53,000
Lead	50	MOE	25	MOE	1	MOE	50	MOE*	32
Mercury	1	MOE	0.2	MOE	0.5	MOE	0.3	MOE*	0.7
Arsenic	50	MOE	100	MOE			8	MOE*	
Zinc	5,000	MOE	30	MOE			100	MOE*	163
Nickel	1.34	EPA	25	MOE			25	MOE*	48
Phenol	2	MOE	1	MOE					
PCB	3	MOE	0.001	MOE	2	MOE	0.05	MOE*	0.078
Endosulfan I, II	74	EPA	0.003	MOE	0.1	HW	0.5		
Heptachlor (and HE)	0.00272	EPA	0.001	MOE	0.2	HW			
DDT and metabolites	0.00024	EPA	0.003	MOE	5	MOE			
Toxaphene	5	MOE	0.008	MOE					
Pentachlorobenzene	74	EPA	50	EPA					
Hexachlorobenzene	0.0072	EPA	50	EPA					
Tetrachlorobenzene	38	EPA	50	EPA					
Mirex			0.001	MOE	0.1	MOE			
Aldrin (and Dieldrin)	0.7	MOE	0.001	MOE	0.2	HW			
Endrin	0.2	MOE	0.002	MOE	0.1	HW			
Lindane (-BHC)	4	MOE	0.01	MOE	0.2	HW			
Chlordane	7	MOE	0.06	MOE	0.1	HW			
Methoxychlor	100	MOE	0.04	MOE	0.1	HW			
PCP	10	WHO	0.5	MOE	3	HW			
Trichlorophenol (2,4,6)	10	WHO	970	EPA					
Tetrachlorophenol (2,3,4,6)			1.0	MOE					
Malathion			0.1	MOE					
Diazinon			0.08	MOE					
PAH			0.6	MOE					

HW: Food and Drug Act Regulations, 1987.

MOE: Water Management Goals, Policies and Objectives, 1984 (Tables 1 and 4).

MOE: Persaud and Wilkins, 1975*.

WHO: Guidelines for Drinking Water Quality, Vol. 2. 1984.

IJC: Great Lakes Water Quality Agreement. 1978; Reports of the Aquatic Ecosystem Objectives Committee. 1980, 1981, 1983a, 1985.

EPA: Water Quality Criteria Documents. Federal Register 45:99318. 1980. Quality Criteria for Water. 1976.

Sediment Background: Mudroch et al. 1986. Pre-industrial horizons, Lake Ontario depositional areas.

Picton, Picton Marsh and Demorestville creeks. Also, copper was measured in the STP effluents of Trenton, Belleville, Deseronto, Napanee and Picton.

- Zinc periodically exceeded the MOE's protection of aquatic life objective (i.e., 30 ug/L) in the Moira and Napanee rivers, and in Millhaven and Picton creeks. Zinc was also found in the STP effluents at Napanee and Picton.
- Lead levels have exceeded the provincial protection of aquatic life objective (i.e., 25 ug/L) in the Trent, Moira, Napanee and Sawguin rivers, in Picton Creek, and in Picton Marsh Creek. Elevated levels of lead have been measured in the Napanee and Picton effluents.
- Nickel has occasionally been detected in concentrations greater than the United States Environmental Protection Agency's drinking water objective (i.e., 1.34 ug/L) in the Trenton, Belleville, Napanee and Picton STP effluents, and in water samples taken from the Trent, Moira, Salmon, Napanee and Sawguin rivers, and in Demorestville and Picton Marsh creeks. However, the MOE's aquatic life objective for nickel (i.e., 25 ug/L) has not been exceeded in Bay of Quinte surface waters.
- Levels of cadmium have historically exceeded the MOE's ambient water quality objectives for aquatic life (i.e., 0.2 ug/L) in the Trent River, Sawguin River, Napanee River, Demorestville Creek, Millhaven Creek and Picton Marsh Creek.
- The MOE's phenol objective for protecting against tainting of edible fish flesh (i.e., 1 ug/L) has been exceeded from time to time in the Trent River, Trenton Bay, The Bay of Quinte at Belleville, Sawguin River, Demorestville Creek and Picton Marsh Creek. In the Trent River, phenolic loads have been traced to the Trent Valley Paperboard Mills at Glen Miller, and the Domtar Wood Preserving and Domtar Packaging plants at Trenton. In 1978, elevated levels of pentachlorophenol (PCP), a potent

biocide used mainly as a wood preservative, were found in the Trent River downstream of the Domtar Wood Preserving property (Beak 1988).

- A 1987 analysis of discharge quality at Domtar Wood Preserving revealed that discharge levels of phenol and PCP were not, for the most part, in compliance with either the MOE's Southeast Region Divisional Standards (i.e., 200 ug/L and 50 ug/L respectively) or the company's 1982 Certificate of Approval (i.e., 20 ug/L and 100 ug/L respectively). Plant averages reported for each of the "north", "south" and "far north" outfalls for phenol were 154 ug/L, 141 ug/L and 580 ug/L respectively, and for PCB, 490 ug/L, 1,900 ug/L and 102 ug/L respectively. Phenolic concentrations in process waters and effluents of Bakelite Theromsets Limited have exceeded the 96-hour LC50 range for rainbow trout (Verschveren 1983); however, no impacts in the Bay of Quinte were demonstrated.
- Polychlorinated biphenyl (PCB) has been detected in the Trent and Moira rivers. However, the concentration is less than the analytical detection limit (which, in turn, is considerably less than the provincial objective for protection of aquatic life). Accordingly, the historical data cannot be compared with confidence to any established objectives.
- In the past ten years, levels of: (1) cadmium in the Trent, Moira, Salmon and Napanee rivers; (2) zinc in the Moira and Napanee rivers; (3) copper in the Moira and Napanee rivers, and Demorestivlle Creek; (4) nickel in the Napanee River; (5) and iron in Picton Creek; and (6) phenols in the Moira River have declined. While changes in analytical detection limits since 1973 may be a factor in contributing to these long-term declines, temporal patterns of contaminant levels have also varied between Bay of Quinte tributaries. Accordingly, a portion of the long-term reductions may be real (Beak 1988), and the results of past and ongoing abatement programs, legislation and pollution clean-up operations.

3.1.9.2 1988 Heavy Metals

Bay of Quinte open waters: The above-noted heavy metal reductions in Bay of Quinte surface waters were confirmed in a 1988 sampling program. In this regard, water samples were collected at 15 open-water stations, six tributary locations, six STP discharge streams, and four industrial waste sources on two days in May and two days in August. All samples were analyzed for aluminum, arsenic, cadmium, chromium, copper, iron, mercury, manganese, nickel, lead and zinc (Table 24). Initial results suggest ambient water quality objectives for surface waters were exceeded only for copper (7% of samples), cadmium (6% of samples) and iron (2% of samples). The provincial guideline for cadmium to protect aquatic life is 0.2 ug/L; most cadmium exceedences were single samples of concentrations about 8 ug/L. These samples were sporadically distributed. The same samples exceeded copper objectives, and one exceeded the iron objective; additionally, other metals were above average, and the replicate samples showed considerably lower concentrations. This suggests contamination during sampling, and that the true extent of the Provincial Water Quality Objective exceedences may be very low.

Industries and sewage treatment plants: Table 25 summarizes the source results for aluminum, chromium, copper, iron, mercury, manganese and zinc. Cadmium was not detected in any source sample. Arsenic and lead were found in only a small number of source samples, except at Domtar Wood Preserving where arsenic was found in every sample at concentrations between 2 ug/L and 71 ug/L. Of the ten source samples, Domtar Packaging is a major source of almost every metal; Domtar Wood Preserving is also an important source of iron, and Trent Valley Paperboard is an important source of aluminum, copper, manganese and zinc. At the Trenton STP, several heavy metals were found at high concentrations (i.e., copper, iron and zinc). Other metals were relatively low, except for aluminum at the Deseronto, Napanee and Picton STPs; however, aluminum is of less importance toxicologically than the other metals.

Tributaries: Aluminum, iron, mercury and manganese in the Napanee River, and

Table 24. Heavy metal statistics (ug/L), Bay of Quinte, 1988
(unpublished Ministry of the Environment data).

Metal	Detection limit	PWQO	Mean	Standard deviation	Maximum	% > PWQO
Aluminum (total)	10	--	90	78	500	--
(filtered)	10	--	43	36	410	--
Chromium (total)	0.5	100	2.6	2.5	18	0
(filtered)	0.5	--	3.6	4.5	38	--
Copper (total)	0.5	5	2.7	3.0	26.0	6.7
(filtered)	0.5	-	5.1	5.3	27.0	--
Iron (total)	20	300	103	82	560	2.4
(filtered)	20	--	28	18	110	--
Manganese (total)	0.5	--	34	23	90	--
(filtered)	0.5	--	3.8	5.1	45	--
Zinc (total)	0.5	30	2.5	3.1	29	0
(filtered)	0.5	--	7.0	10.1	79	--
Arsenic (total)	1.0	100	<1.0 ^a	--	4 (T)	0
(filtered)	1.0	--	<1.0 ^a	--	4 (T)	--
Cadmium (total)	0.2	0.2	<0.2 ^a		85	6
(filtered)	0.2	--	<0.2 ^a		85	--
Mercury (total)	0.01	--	<0.01 ^a		0.17	--
(filtered)	0.01	0.2	0.01 ^a (T)		0.18	0
Nickel (total)	2.0	25	<2.0 ^a		25	0
(filtered)	2.0	--	<2.0 ^a		60	--
Lead (total)	5.0	25 ^b	<5.0 ^a		12 (T)	0
(filtered)	5.0	--	<5.0		14 (T)	--

a - median (ug/L)

b - based on alkalinity >80mg/L as CaCO₃

(T) - trace amount, below level of quantification

PWQO - Provincial Water Quality Objective

Table 25. Median concentrations of heavy metals in sewage and industrial discharges and tributaries, Bay of Quinte; all data are in ug/L.

Station	Aluminum	Chromium	Copper	Iron	Mercury	Manganese	Zinc
Sewage Treatment Plants							
Trenton	60	6	32	500	40	110	31
Trenton CFB	240	< 5	6	< 50	30	13	20
Belleville	70	10	12	630	30	130	19
Deseronto	550	11	13	120	40	25	21
Napanee	310	12	6	580	40	170	16
Picton	680	5	9	70	40	14	18
Industries							
Domtar WP	210	< 5	6	1,400	< 10	140	9
Domtar Pkg	5,450	50	109	1,300	510	550	230
Trent Valley	2,600	8	12	450	70	380	85
Bakelite	250	7	5	260	20	51	< 5
Tributaries							
Trent River, west side	81	2	2	100	30	36	2
Trent River, east side	89	1	3	100	<10	40	1
Moirs River	70	5	3	70	20	34	2
Salmon River	105	4	4	115	30	39	3
Napanee River	310	2	3	335	80	70	2
PWQO*	--	100	5	300	0.2	--	30

* - Provincial Water Quality Objectives for all parameters are in an unfiltered sample, except for mercury which is in filtered water (MOE 1984).

chromium in the Moira River were found to be above Bay of Quinte levels. Arsenic was also found in the Moira River (i.e., 3 ug/L in May and 15 ug/L in August). In comparison to earlier studies (Beak 1988), zinc levels in 1988 in the Napanee River were lower, while concentrations of cadmium and copper were similar. Lead may be lower as well; it was not found at a detection level of 5 ug/L in 1988. Copper in the Moira River in 1988 was at a similar level to that of 1984 to 1986, and 1987 values cannot be compared as there was only one sample. Zinc appears to be significantly lower in 1988; in this regard, the 1988 median was 2 ug/L; the approximate 1982 to 1987 range was 10 ug/L to 20 ug/L.

3.1.9.3 1988 Toxic Organic Contaminants

Historically, information on concentrations and loadings of toxic organics in the Bay of Quinte is limited (Beak 1988). Analyses were performed on water or effluent samples collected in 1988 from six STPs, four industries (i.e., Domtar Wood Preserving, Domtar Packaging, Trent Valley Paperboard and Bakelite Thermosets Limited) and six tributaries. Samples were obtained from each location in May, and from most locations in August. A summary of detections by station type is provided in Table 26.

The most frequently detected compound was PCP; a summary of concentrations found is given in Table 27. Concentrations at the Domtar Wood Preserving outfall ranged from 27 ug/L to 2,200 ug/L. At Trent Valley Paperboard, concentrations ranged from 0.61 ug/L to 3.5 ug/L. These resulted in maximum concentrations at the mouth of the Trent River of 0.580 ug/L (i.e., west side of river) and 0.710 ug/L (i.e., east side), which diluted to 0.08 ug/L to 0.189 ug/L in the Bay at Trenton, and trace amounts midway between Trenton and Belleville on the same day. On other days, concentrations in the bay were at trace to non-detectable levels. PCP was also found in effluent samples from every STP (i.e., total of 65% of all samples), with the maximum single sample concentration being 0.9 ug/L (i.e., Trenton STP).

Tri - and tetrachlorophenols were found in the Domtar Wood Preserving

Table 26. Summary of detections, organic scans (% of samples), Bay of Quinte, 1988 (unpublished Ministry of the Environment data).

Compound	Bay	Tributaries	STPs	Industries
Chlorophenols				
2,3,4-trichlorophenol	0	0	0	13
2,4,5-trichlorophenol	0	0	3	19
2,4,6-trichlorophenol	0	0	57	39
2,3,4,5-tetrachlorophenol	0	0	0	26
2,3,5,6-tetrachlorophenol	0	23	8	26
pentachlorophenol	31	50	65	87
PCB-organochlorines				
PCB (total)	0	0	0	0
Heptachlor	0	0	11	9
Aldrin	0	0	0	0
pp-DDE	0	0	0	0
Mirex	0	0	0	0
α -BHC	19	7	21	13
β -BHC	0	0	8	0
Γ -BHC	0	7	66	9
α -chlordane	0	0	0	0
Γ -chlordane	0	0	40	0
oxychlordane	0	0	3	26
op-DDT	0	0	5	0
pp-DDD	0	0	0	0
pp-DDT	0	0	3	0
DMDT methoxychlor	0	0	3	18
heptachlor epoxide	0	0	8	9
endosulfan I	0	0	11	13
dieldrin	0	0	0	4
endrin	0	0	0	4
endosulfan II	0	0	5	4
endosulfan sulfate	0	0	3	13
octachlorostyrene	0	0	0	0
Chlorobenzenes				
1,2,3-trichlorobenzene	0	0	18	4
1,2,4-trichlorobenzene	0	0	3	0
1,3,5-trichlorobenzene	0	0	0	0
1,2,3,4-tetrachlorobenzene	0	0	3	0
1,2,3,5-tetrachlorobenzene	0	0	0	0
1,2,4,5-tetrachlorobenzene	0	0	0	0
pentachlorobenzene	0	0	0	0
hexachlorobenzene	0	0	11	4
2,4,5-trichlorotoluene	0	0	0	0
2,3,6-trichlorotoluene	0	0	0	9
2,6,a-trichlorotoluene	0	0	0	0
hexachloroethane	0	0	13	4

STP - Sewage treatment plant

Table 27. Pentachlorophenol levels* and statistics in the Bay of Quinte, 1988.

Station	N		N>DL		Median		Maximum	
	M	A	M	A	M	A	M	A
Sewage Treatment Plants								
Trenton	1	4	0	3	---	0.145	---	0.900
Trenton CFB	2	4	2	2	0.075	0.170	0.080	0.330
Belleville	3	4	3	2	0.120	0.280	0.135	0.500
Deseronto	3	3	3	3	0.145	0.030	0.155	0.090
Napanee	3	4	1	3	<0.050	0.055	0.100	0.060
Picton	2	4	0	2	---	0.035	---	0.035
Industries								
Domtar WP	1	4	1	4	230	565	230	2,200
Domtar Pkg	1	4	1	4	0.910	0.690	0.910	1.400
Trent Valley	2	4	2	4	0.620	1.450	0.630	3.500
Bakelite	3	4	0	4	---	0.090	---	0.170
Tributaries								
Trent River, west side	3	4	2	4	0.020T	0.450	0.060T	0.580
Trent River, east side	3	4	3	4	0.030T	0.600	0.080T	-.710
Moirs River	2	4	0	0	---	---	---	---
Salmon River	0	4	0	0	---	---	---	---
Napanee River	0	0	0	0	---	---	---	---
Marsh Creek	0	2	0	0	---	---	---	---

* - Detection Limit 0.010 to 0.050 ug/L

N - number of samples collected

N>DL - number of samples above detection limit (includes "trace" - <T)

M - May collection period

A - August collection period

T - "Trace" <T

effluent 90% of the time. Concentrations ranged from non-detectable to 11.8 ug/L for 2,3,4,5-tetrachlorophenol. Several other chlorophenols were found in STP effluents, the most frequently being 2,4,6-trichlorophenol. At the mouth of the Trent River only trace amounts of 2,3,5,6-tetrachlorophenol were found. None of these compounds were found in Bay of Quinte water at conventional detection limits.

PCBs were not reported from any of the samples. The most frequently detected organochlorine compounds were alpha-benzene hexachloride and gamma-benzene hexachloride, with the former being the only organochlorine found in trace amounts in any bay sample.

Organic compounds important in pesticide formulations (i.e., heptachlor, gamma-chlordane and endosulfan I) were found in more than 10% of the STP samples. As well, oxychlordane, DMDT methoxychlor, endosulfan I and endosulfan sulphate were found in more than 10% of industrial samples. However, concentrations of these compounds were quite low and highly variable; frequently, one sample of a replicate pair would have a non-detectable level while the other had considerably higher levels. For example, on September 1, methoxychlor was 0.370 ug/L in one Domtar Packaging effluent sample, and not detected in the replicate.

Chlorobenzenes were not found in any tributary or Bay of Quinte water samples; on occasion, they were detected in source samples. More specifically 1,2,3-trichlorobenzene, and hexachlorobenzene, were found in slightly more than 10% of the STP samples.

Polynuclear aromatic hydrocarbon (PAH) was found in the effluent stream of Domtar Wood Preserving. Five PAH compounds were found at levels of up to 0.2 ug/L on the replicate samples of September 1; the MOE's ambient water quality objective for total PAH is 0.6 ug/L. Several phthalates and other acid-extractables were also measured in the August samples; bis-2-ethyl hexyl phthalate was found at several STPs as well as at the Domtar Wood Preserving and Trent Valley Paperboard plants. The maximum concentration at the Domtar

Wood Preserving was 465 ug/L; however reproducibility was poor. Di-n-butyl and butylbenzyl phthalates were also found in some of the effluent samples from the above two industries.

Organophosphorus insecticides were only occasionally found in STP and industrial samples. One sample on May 9 from Trent Valley Paperboard contained 0.57 ug/L of diazinon and 8.38 ug/L of malathion; one sample on May 5 at the Napanee STP contained 0.30 ug/L of diazinon, and one sample on May 9 at the Trenton CFB STP contained 0.06 ug/L of malathion. Otherwise, nothing was found.

A single sample from each source, collected in August 1988, was analyzed for chlorinated dioxins (CDD) and furans (CDF). Most of the positive detections were at Domtar Wood Preserving: 0.004 ug/L 6-CDD, 0.024 ug/L 7-CDD, 0.220 ug/L 8-CDD, 0.0003 ug/L 4-CDF, 0.0003 ug/L 5-CDF, 0.0029 ug/L 6-CDF, 0.0056 ug/L 7-CDF, 0.011 ug/L 8-CDF. At Trent Valley Paperboard, 8-CDD was also found (i.e., 0.0008 ug/L), as well as at the Trenton STP (i.e., 0.0007 ug/L) and Domtar Packaging (0.012 ug/L). All other analyses were below detection limits of 0.0001 to 0.001 ug/L

3.1.9.4 Drinking water surveillance program

The Ministry of the Environment's Drinking Water Surveillance Program was initiated in 1986 to monitor water quality at municipal water treatment plants. The program's objectives are to provide:

- reliable information on drinking water quality;
- a mechanism to identify objective exceedances;
- a framework for detecting long-term trends;
- rationale for remedial actions; and
- an indication of treatment efficiency of plant processes.

Currently, 44 water treatment plants are being monitored in Ontario. In the Bay of Quinte area, biweekly samples are being collected from the Belleville,

Deseronto and Bayside School plants and distribution systems. The samples are analyzed for as many as 188 organic and inorganic compounds, and for a variety of bacteria. To assess quality, the results are compared with various health related and aesthetic guidelines including the Ontario Drinking Water Objectives (ODWO), Health and Welfare Canada (HW), the World Health Organization (WHO) and the United States Environmental Protection Agency (USEPA). In 1987, treated drinking water at the three plants and in their distribution systems met all health related guidelines (see Appendix F-1, F-2 and F-3 for details).

Highlights are as follows.

Belleville: Trihalomethanes (THM) were found at levels as high as 204 ug/L in samples of treated water at Belleville. These compounds form when chlorine reacts with organic substances present in raw or untreated water. The ODWO is 350 ug/L. Phenol was reported at 1.2 ug/L in one sample of treated water; the aesthetic ODWO (i.e., taste impairment) guideline for phenol is 2 ug/L. Hexachloroethane was found in two samples from the distribution system at concentrations of 0.012 ug/L and 0.014 ug/L; the USEPA's ambient water quality guideline is 9.1 ug/L. One sample of treated water contained 0.056 ug/L of chloroaromatic 2,3,6-trichlorotoluene; at present, no known health-related guideline for this compound exists. Finally, aesthetic ODWO's for organic nitrogen and colour were occasionally exceeded in treated water.

Deseronto: THM in treated water reached concentrations of 105 ug/L, and phenol was found in a single treated water sample of 1.0 ug/L.

Bayside School: THM were found at levels up to 151 ug/L in samples of treated water, and non-health related ODWO's for organic nitrogen and temperature were exceeded in a few samples of treated water.

3.2 BACTERIOLOGY

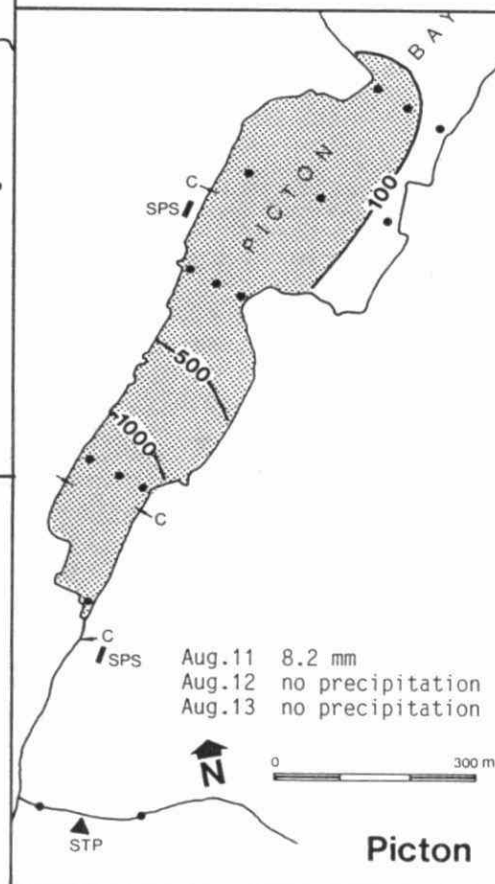
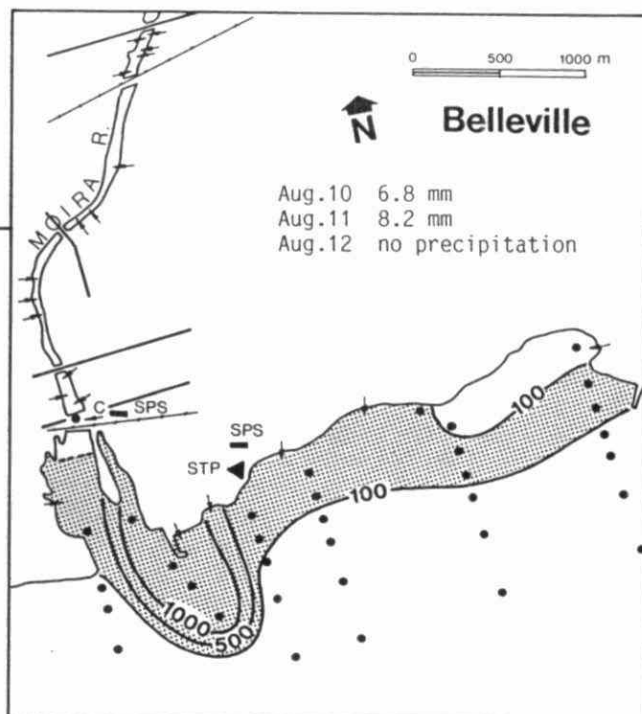
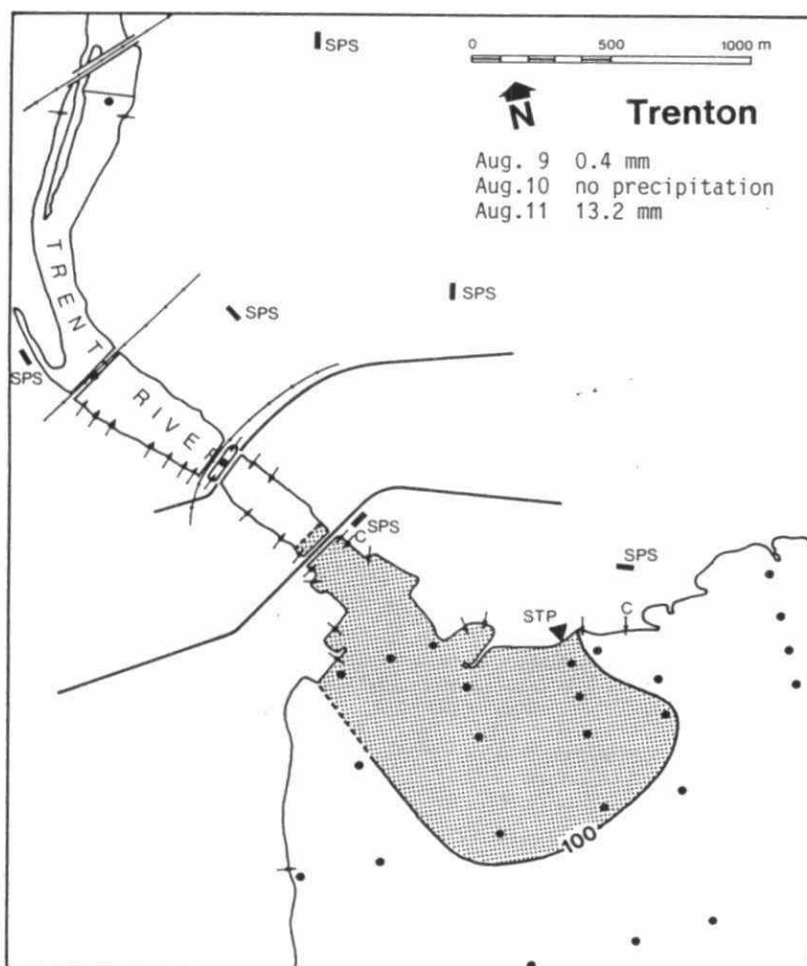
A potential human health hazard exists if the fecal coliform mean density exceeds 100/100 mL for a series of water samples.

In 1970, bacteria were sampled at 28 locations along the entire length of the Bay of Quinte. Highest levels of pollution were found in the urbanized areas, particularly at Picton and Deseronto. Counts throughout the bay were sufficiently high to caution against swimming and bathing and consuming bay water without adequate treatment.

Numerous surveys were undertaken between 1970 and 1987 (Griffiths 1984, Poulton 1986). The results are presented below.

Trenton

- In 1981 and 1982, zones with greater than 100 fecal coliform/100 mL of water extended up to 2 km from the mouth of the Trent River into the Bay of Quinte, under dry and wet weather conditions. The plumes were not caused by discharges from local sewage treatment plants; instead the sources were Domtar Packaging's illegal cross-connections and by-passing, and effluent discharges from the pulp and paper mill. (Figure 14).
- In 1984, samples from the Domtar Packaging effluent, and upstream and downstream from its site on the Trent River were collected and analyzed for fecal coliform, E. coli and Klebsiella pneumonia. On July 24, high counts of all parameters were recorded in the vicinity of the outfall (i.e., 166-48,000 fecal coliform/100 mL; 130-15,000 E. coli/100 mL; and 166-16,000 K. pneumonia/100 mL); counts were substantially lower towards the mouth of the river. By July 31, levels of all three parameters were much lower near the outfall, with maximum levels near the diffuser being 160 fecal coliform/100 mL, 48 E. coli/100 mL and 112



- Legend**
-  Zones, above 100 counts/100 ML of Fecal Coliform Levels
 -  Storm sewer
 -  Combined sewer overflow
 -  STP Sewage treatment plant
 -  SPS Sewage pumping station

Figure 14. Bacteriological results, Trenton, Belleville, Picton, 1981.

K. pneumonia/100 mL. The Ministry of the Environment concluded that discharges were intermittent and that both process and sanitary wastes were being discharged, and recommended that the waste types be separated. Following replacement of a faulty septic tank within the plant, further tests were undertaken. High E. coli levels of unknown origin were detected.

- In 1987, the bacterial zone exceeding the Provincial Water Quality Objective extended about 1 km into the bay from the Trent River (Figure 15). This zone was significantly smaller than the largest bacterial zone found in 1981 (Poulton 1989). In the same survey, Klebsiella bacteria (Figure 16) were found in the Domtar Packaging, the Trent Valley Paperboard and the Trenton sewage treatment plant effluents. The Domtar and the Trenton sewage treatment plant were also sources of E. coli bacteria (Figure 17). As well, the bacterial levels found in the Trent River, under both dry or wet weather conditions suggest possible illegal cross-connections or inflow/infiltration of sanitary sewage into storm sewers in downtown Trenton (Poulton 1989).
- The most frequently sampled beach was Bain Park. The park is near the City's eastern limits and downstream of the local sewage treatment plant. The geometric mean of 100 fecal coliform/100 mL was usually exceeded at this site on the day of or the day following a rainfall event. In 1987, bacteriological levels at Bain Park beach were acceptable for swimming and bathing on six of the eight survey dates. Following rainfalls, bacterial contamination exceeded the 100 fecal coliforms per 100mL of water objective. However, no sources of contamination were apparent.
- The quality of effluent at Canadian Forces Base Trenton's sewage treatment plant was generally good. For example, in 1987, only two of eight daily geometric means exceeding 100 fecal coliforms/100 mL (Figure 15).

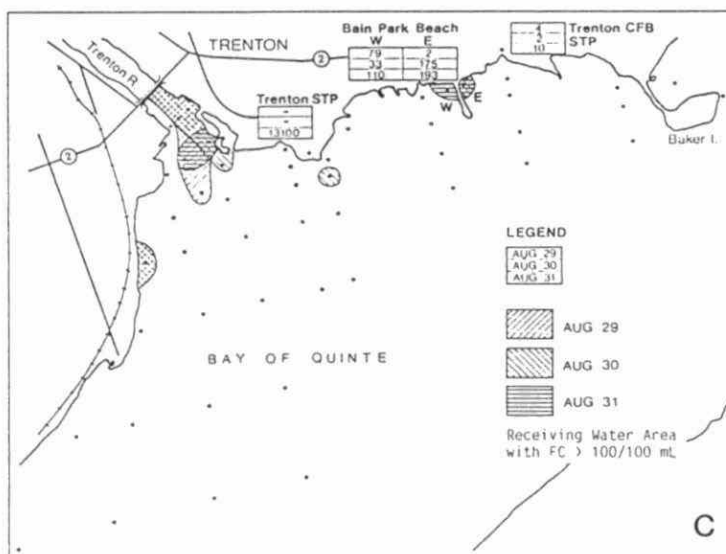
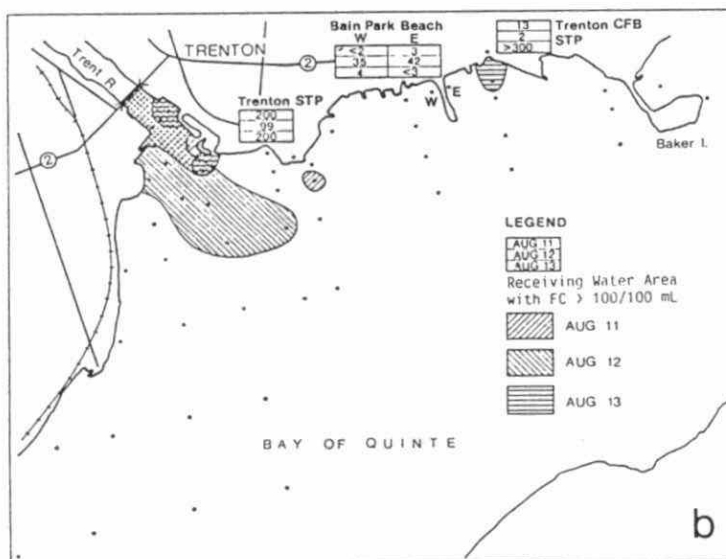
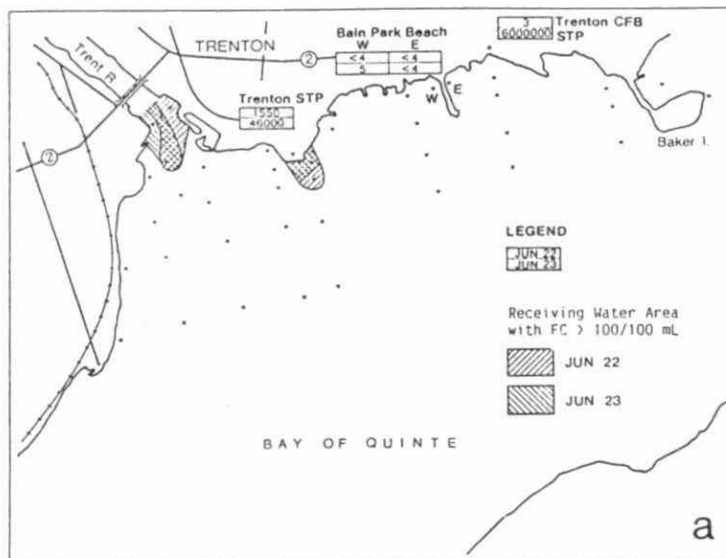


Figure 15. Fecal coliform counts (#/100 mL) observed in the Bay of Quinte at Trenton (a) during June in dry weather, (b) during dry weather in August, and (c) during wet weather in August, 1987 (from Poulton 1989).

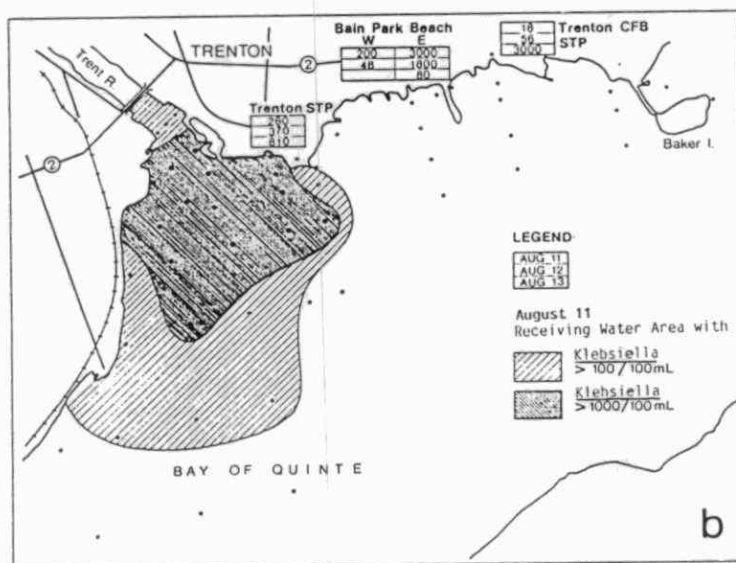
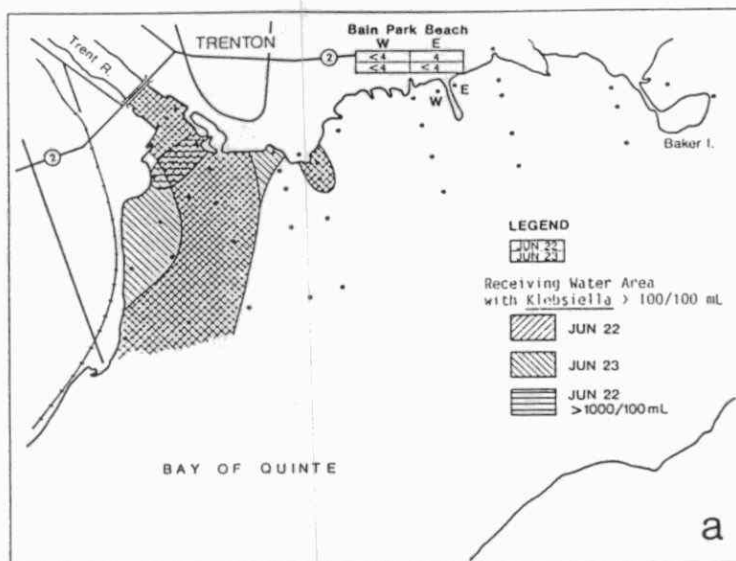


Figure 16. *Klebsiella pneumonia* counts observed in the Bay of Quinte at Trenton (a) during June, (b) during August, 1987. No wet weather data area available for *K. pneumonia* (from Poulton 1989).

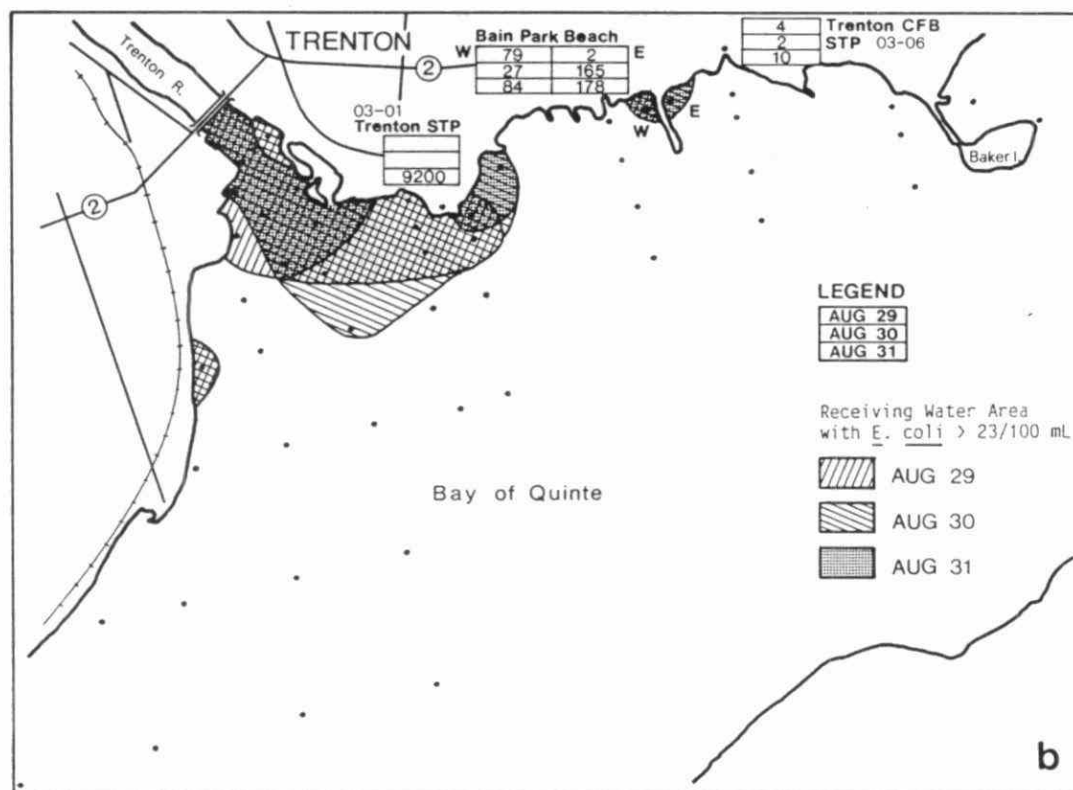
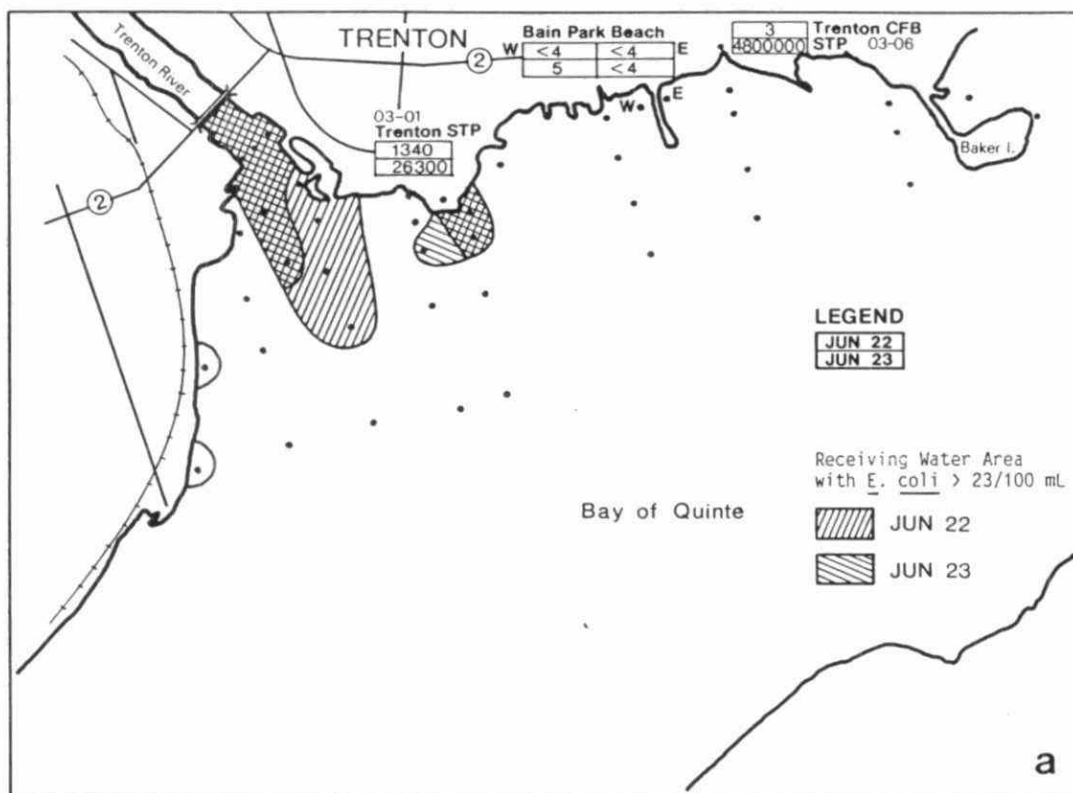


Figure 17. *E. coli* counts observed in the Bay of Quinte at Trenton (a) in June under dry weather conditions, and (b) in August during rainfall (from Poulton 1989).

Belleville

- In 1981, the zone with fecal coliform counts greater than 100/100 mL extended eastwards 3 km along the waterfront following a 15 mm rainfall (Figure 14). These data suggest that raw sewage was being by-passed to the Bay of Quinte at the Belleville sewage treatment plant.
- In 1984, the sewage treatment plant at Belleville was expanded to provide more complete treatment. Subsequent bacteriological surveys revealed that the wet weather plume of fecal coliform bacteria was similar to the plume observed in the 1981 survey, with the Moira River being the primary source (see Figure 18). West of the Moira River, acceptable conditions prevailed in the vicinity of Zwick's Island.
- Studies in 1985 showed that wet weather bacterial loadings originated from numerous storm sewers within the city (Figure 19), as well as, runoff entering the Moira River near the Corby Distilleries outfall north of the city (Figure 20). Under dry weather conditions most of the Moira River within the City of Belleville contained high fecal coliform counts (Figure 21). Storm sewers at Church Street, Pinnacle Street, Bridge Street (east side) and a ditch on the west side at the Canadian National Railway tracks are likely sources of this contamination.
- Riverside Beach on the Moira River has unacceptably high bacterial levels during wet weather and occasionally during dry weather, and has a history of closures owing to high bacterial levels. Two storm sewers north of the beach on the east side of the Moira, plus runoff at the Corby Distilleries outfall are thought to be responsible.

Picton

- A 1981 survey showed that urban stormwater and combined sewage discharges were contaminating downstream waters (Figure 14).

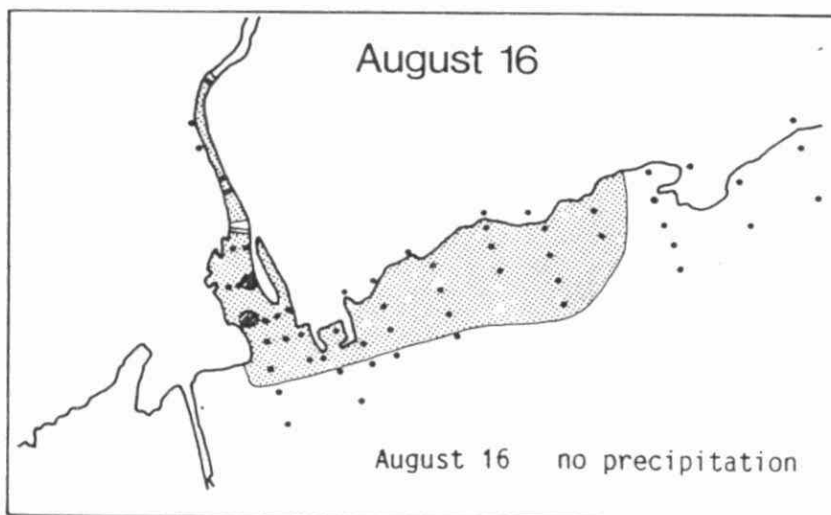
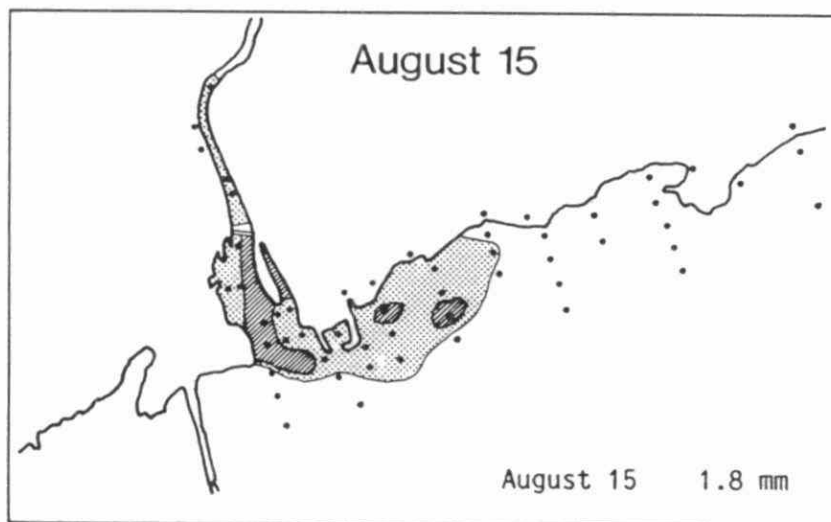
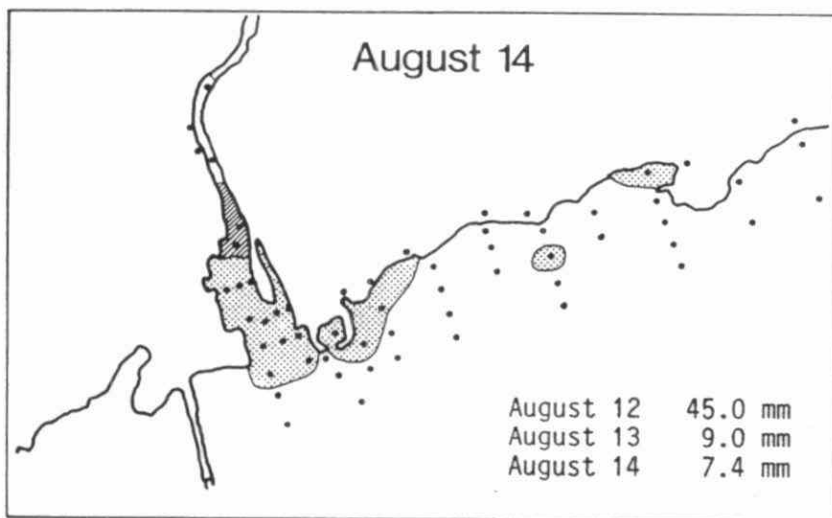


Figure 18.
Fecal coliform counts,
Belleville, August 1984
(Poulton 1986).



Area with fecal coliforms
100-1000/100 ml



Area with fecal coliforms
>1000/100 ml

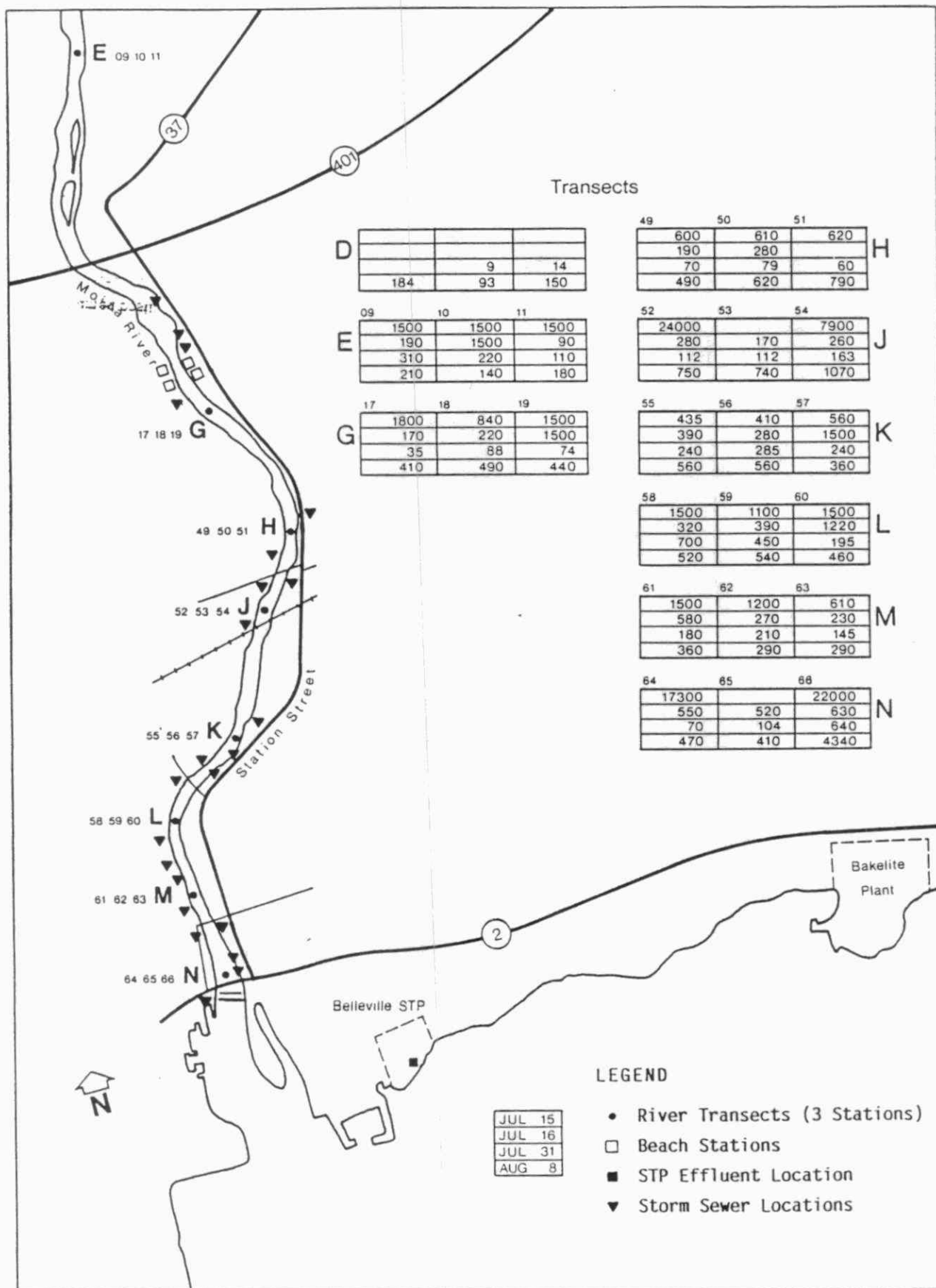


Figure 19. Fecal coliform counts observed during wet weather surveys, Belleville, 1985 (Poulton 1986).

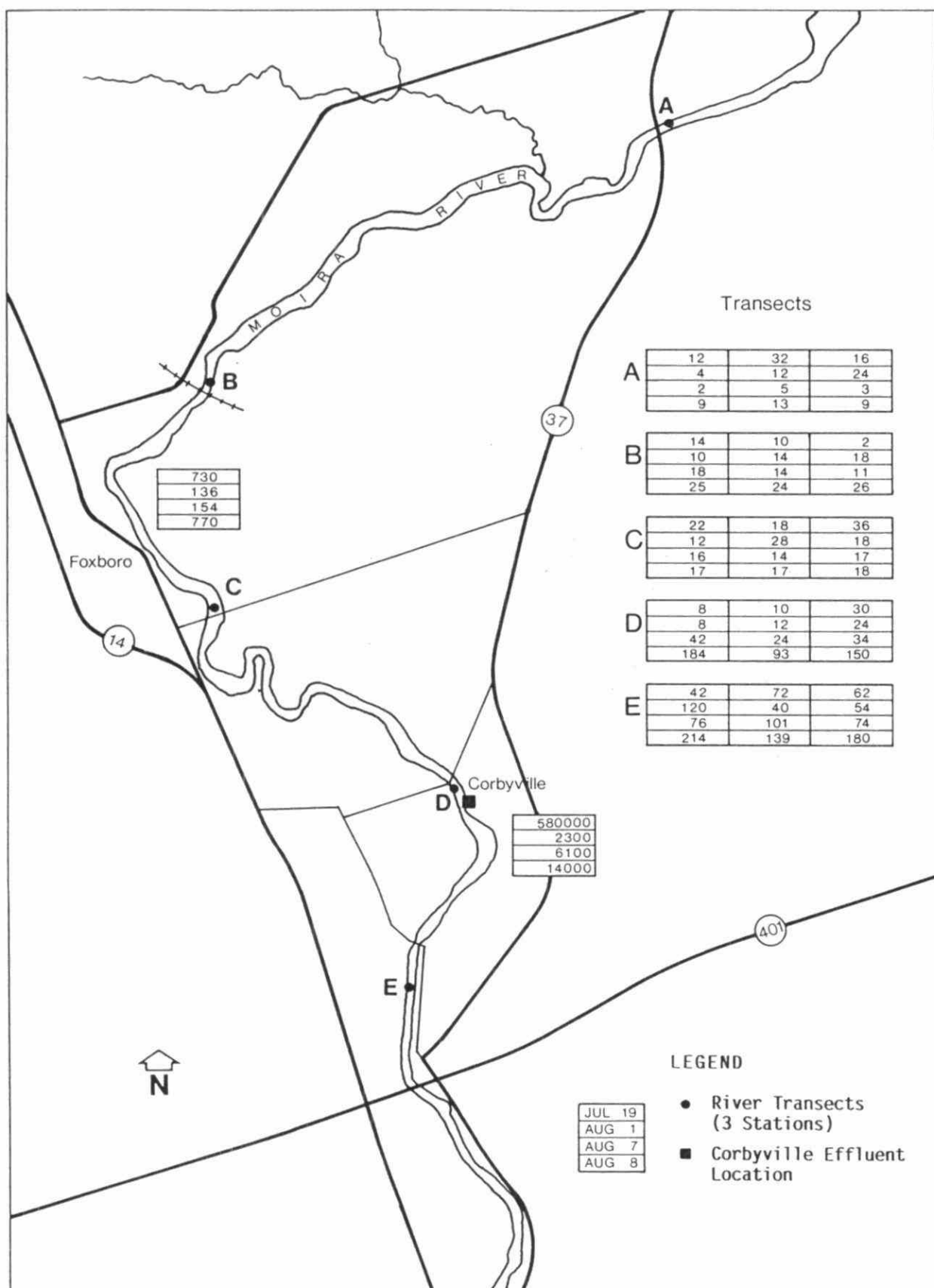


Figure 20. Fecal coliform counts in upstream transects, Belleville, July 19, and August 1, 7, 8, 1985 (Poulton 1986).

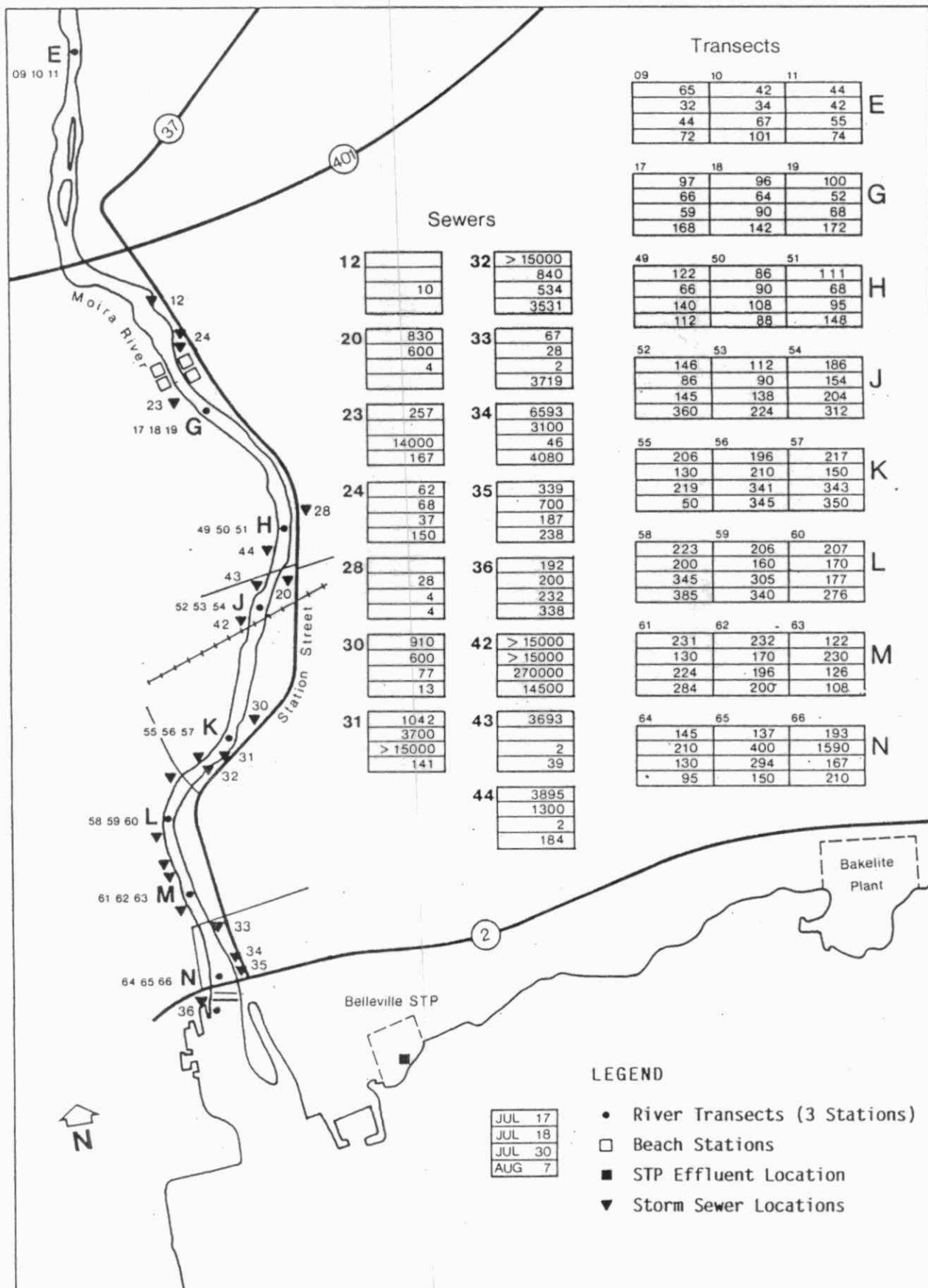


Figure 21. Fecal coliform counts observed during dry weather surveys, Belleville, 1985 (Poulton 1986).

- In 1987, bacteriological contamination was confined in Picton Bay to within one hundred metres of Picton Marsh Creek, and the maximum wet weather bacteriological zone was smaller than the zone of impact measured in 1981 (Poulton 1989). The Picton sewage treatment plant effluent quality was generally high, while effluent quality from the Prince Edward Heights was poor (Figures 22 and 23). Overflowing stormwater discharges and inflow/infiltration may also contribute to the local bacteriological problems (Canviro 1987).

Deseronto

- At Deseronto, occasionally high fecal coliform counts were found in 1981. No impairment from sewage treatment plant discharges was recorded. The effluent from Arctic Gardens Limited (corn processing) may have contributed to the increased counts found at Centennial Park Beach.
- In 1987, there was no evidence of bacteriological impact from the Deseronto sewage treatment plant or the (closed) Arctic Gardens Limited food processing plant at Centennial Park Beach at Deseronto (Figures 24 and 25). However, a zone of high bacterial levels did occur following a rainfall, from the mouth of the Napanee River to the middle of the bay. Canviro (1987) reported that infiltration and inflow occurs at the Napanee sewage treatment plant, although no firm conclusions can be made regarding the plant as a site of contamination.

Summary

- In summary, bacterial contamination occurred in the nearshore Bay of Quinte and in rivers flowing into the bay. Specifically, the lower reaches of the Trent River, the Moira River below Corbyville, at Riverside Beach and within much of the City of Belleville, at Centennial Park Beach in Deseronto, and Picton Bay are periodically contaminated.

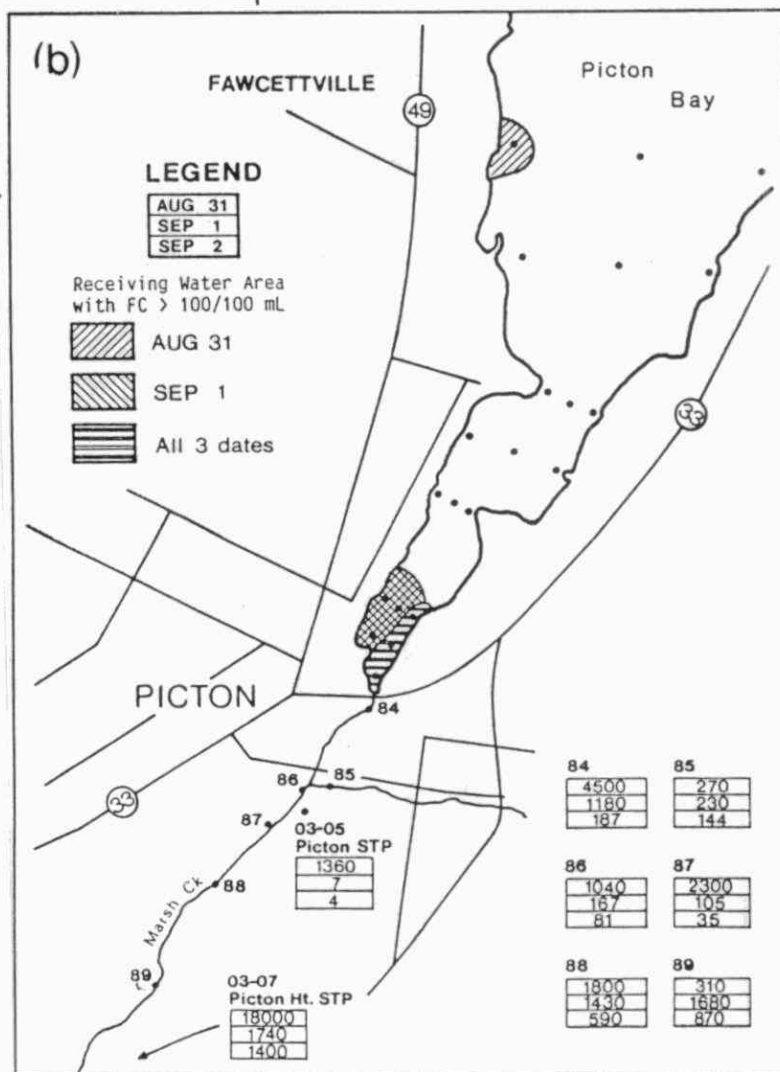
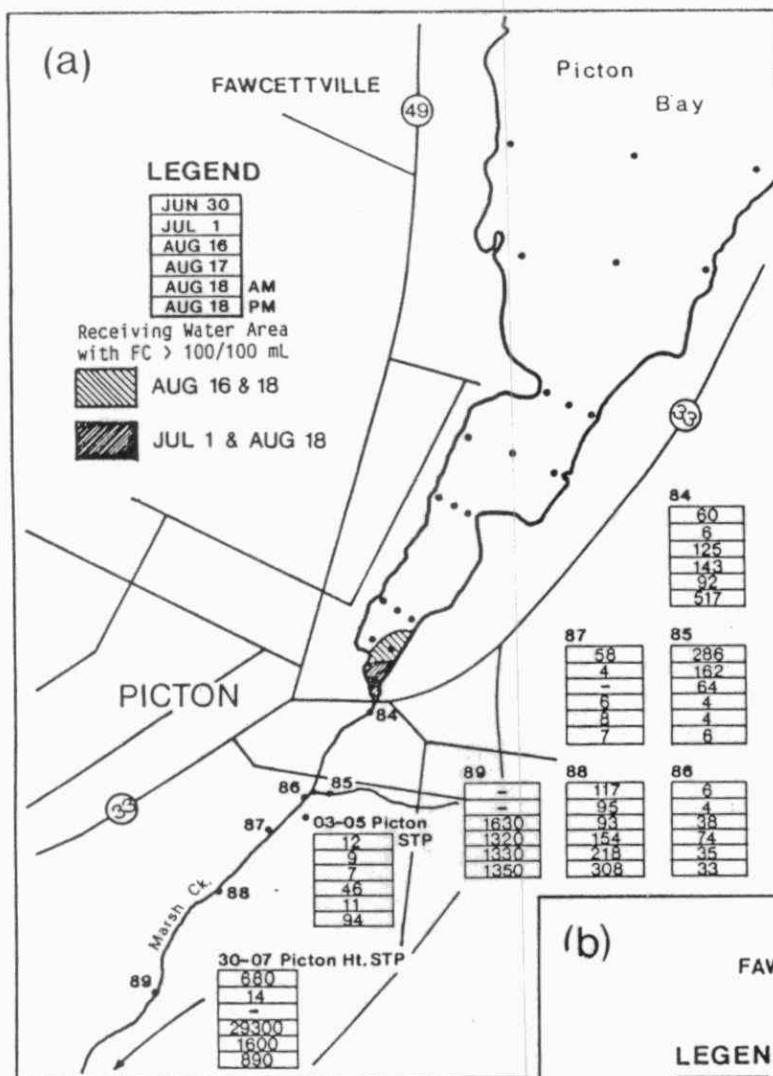


Figure 22. Fecal coliform counts (a) observed in June and August in dry weather, and (b) in September in wet weather at Picton, 1987 (from Poulton 1989).

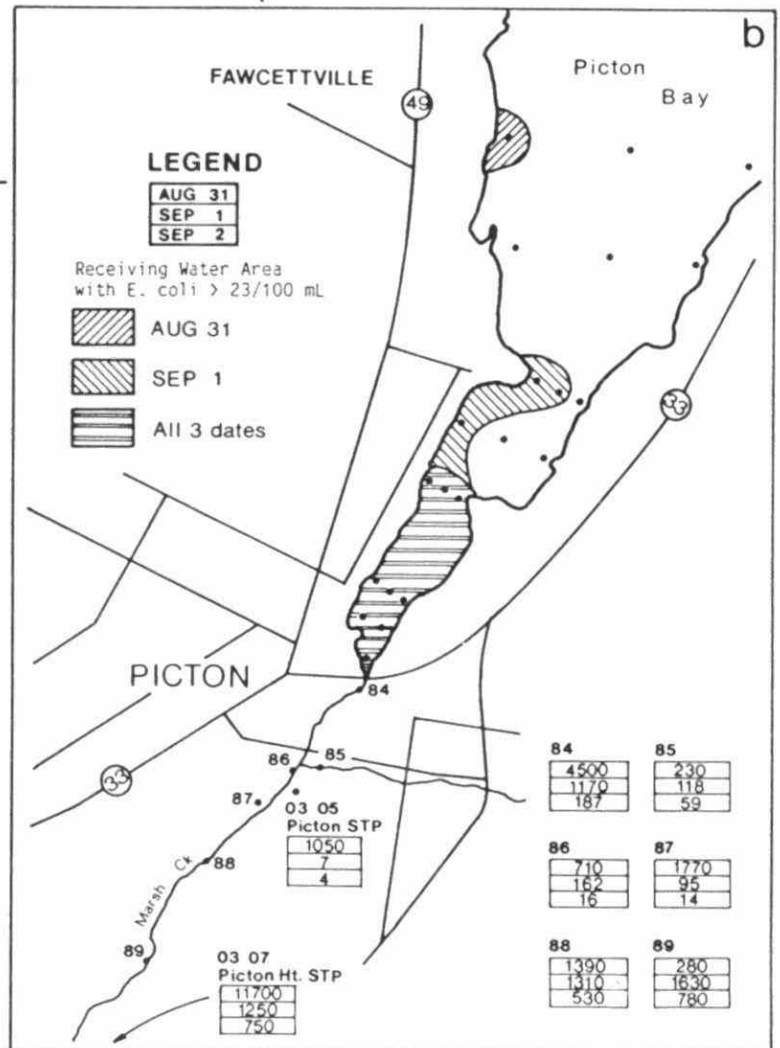
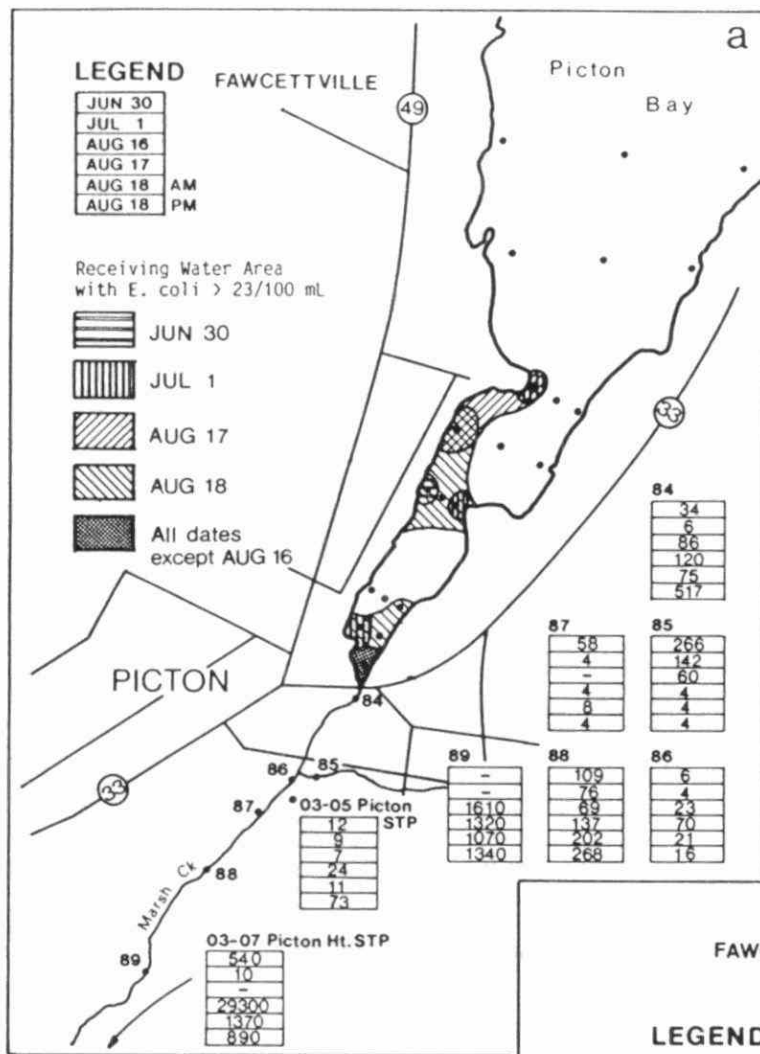


Figure 23. *E. coli* counts observed (a) in June and August in dry weather, and (b) in September in wet weather at Picton, 1987 (from Poulton 1989).

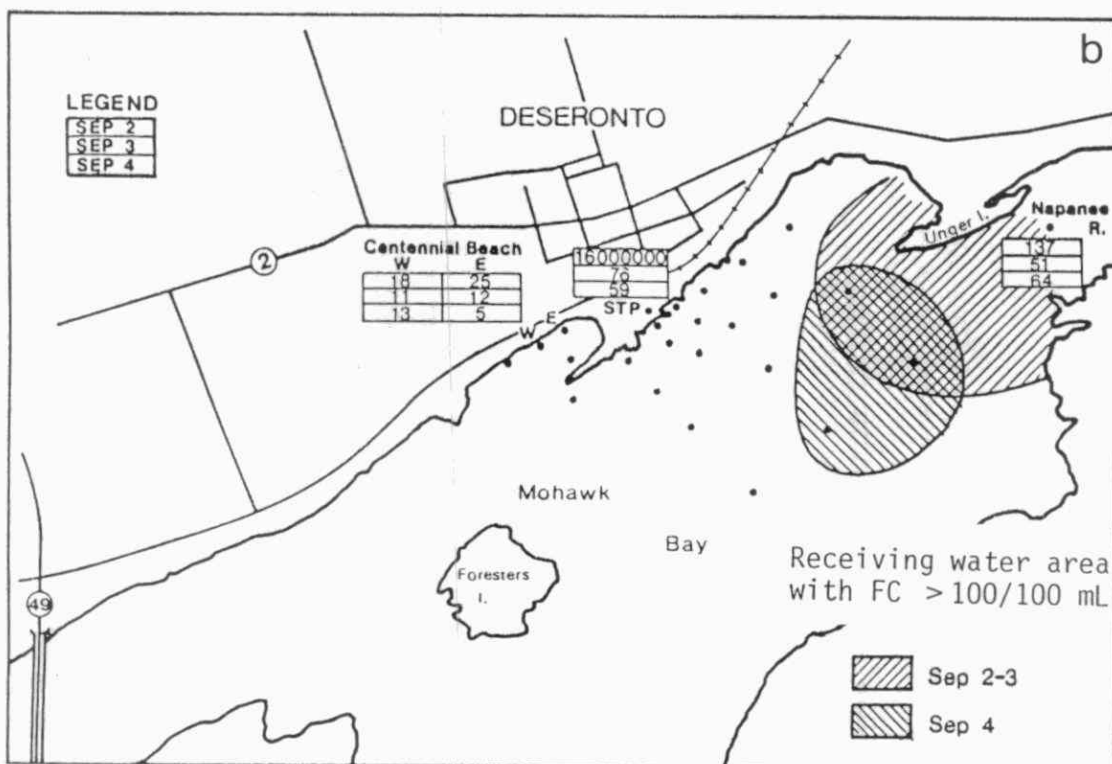
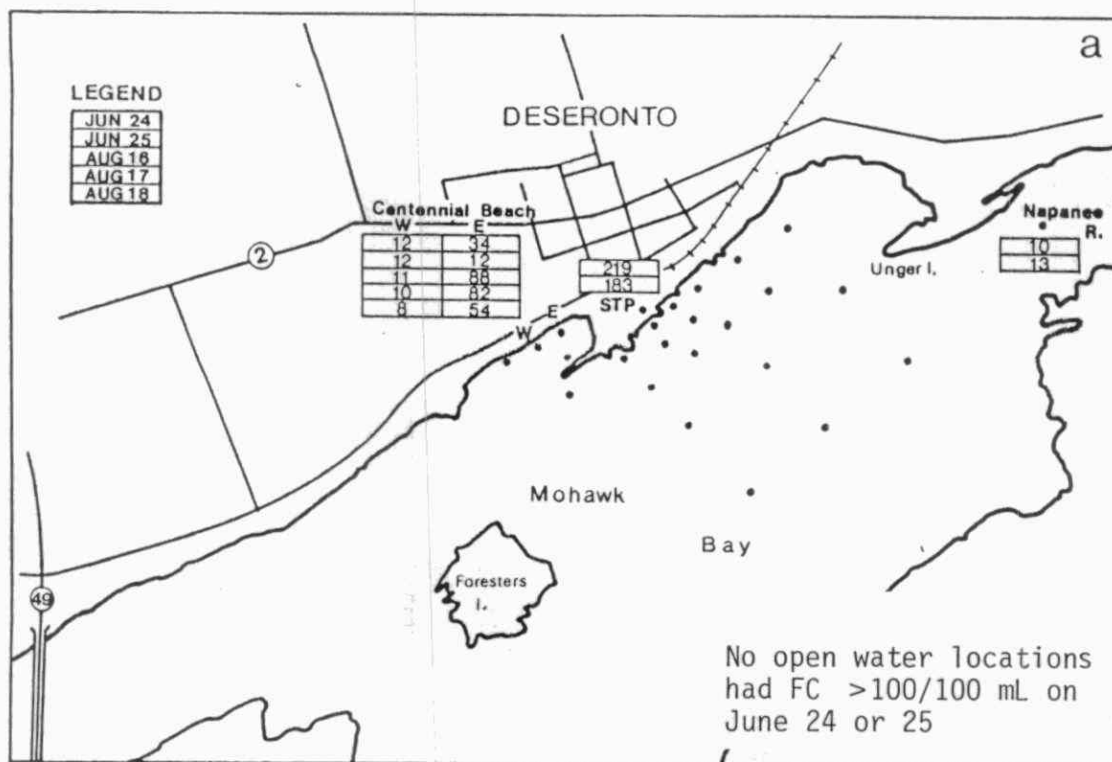


Figure 24. Fecal coliform counts observed (a) in June and August in dry weather, and (b) in September in wet weather at Deseronto, 1987 (from Poulton 1989).

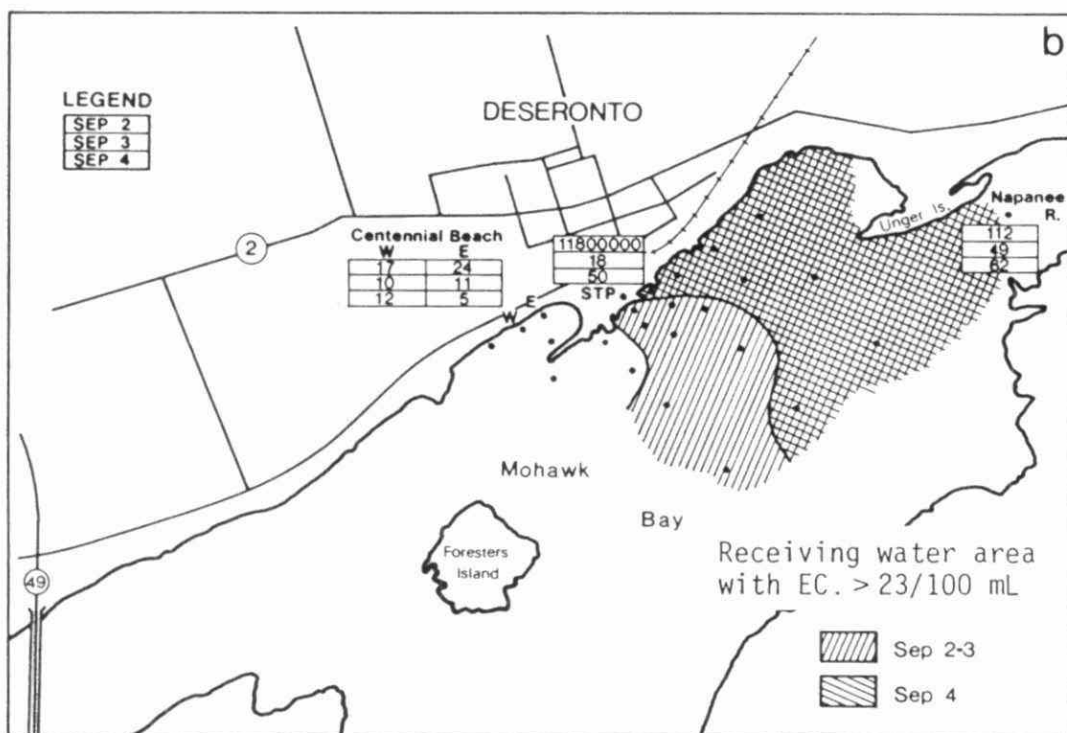
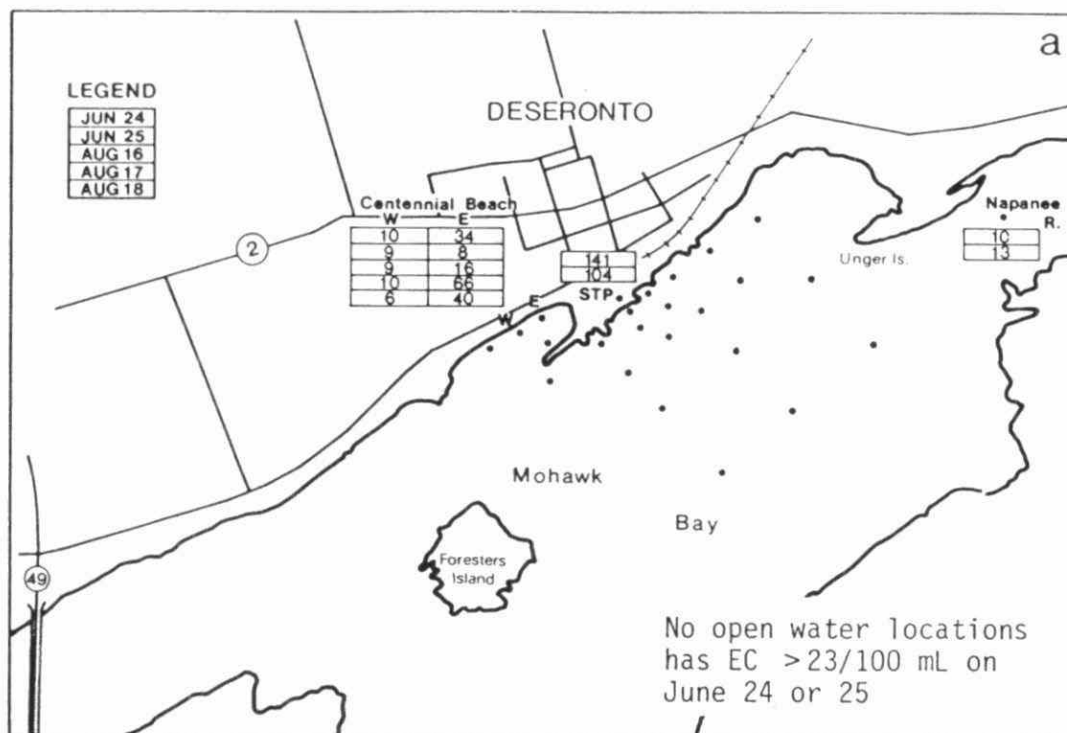


Figure 25. *E. coli* counts (a) observed in June and August in dry weather, and (b) in September in wet weather at Deseronto, 1987 (from Poulton 1989).

3.3 SEDIMENTS

3.3.1 Introduction

Sediments deposited on lake bottom are composed mainly of two types of soil particles: eroded particles which are transported by streams into the lake, and biological material derived from the biota living in the lake water. Sediments of Lake Ontario contain 90-99% mineral (or inorganic) material, and 1-10% organic matter. The bulk of the sediments is derived from glacial tills and clays and surface soils which form the land cover of the drainage basin. Consequently, the geology of the lake's drainage basin determines the composition of the inorganic material in the sediment. Dead algae, zooplankton, fish and plant material settling on the bottom form the sediment organic matter. In addition, nutrients, toxic metals and organic contaminants can accumulate as a result of industrial, domestic and agricultural activities within a system's drainage basin.

3.3.2 General Features

The texture of sediments in the Bay of Quinte was investigated in the upper bay in the early 1970s (Damiani and Thomas, 1974). It was found that coarser sand deposits, tills and glacio-lacustrine clays occur in nearshore zones, in particular, along the northern shore. In this area, the tills crop out discontinuously and are overlain by glacio-lacustrine clays. The offshore deposits were composed predominantly of finer material (i.e., silty clays having particle sizes $<63\mu\text{m}$). Compared with Lake Ontario, the upper bay sediments contain higher quantities of silt (i.e., particle sizes between $4\mu\text{m}$ and $63\mu\text{m}$), similar quantities of sand (i.e., particle sizes $>63\mu\text{m}$), and lower quantities of clay (i.e., particle sizes $<4\mu\text{m}$). These differences were attributed to the shallow water nature of the upper bay in which high turbulent energy causes the transport of the fine clay size particles eastward through Telegraph Narrows.

The drainage basin of the Bay of Quinte is located mainly in limestones and shales. Consequently, high concentrations of calcium carbonate occur in the sediments at the mouth of the Moira River, decreasing eastward and spreading in a plume-like form into the western part of the upper bay. This distribution suggests that inorganic carbon in the sediments is of detrital origin, with the Moira River serving as the major source. Additional sources of natural carbonate from local limestones were observed at Telegraph Narrows and in Muscote Bay. The mean value of 7.58% for inorganic carbon in sediments of the upper bay is significantly higher than that observed for Lake Ontario sediments (3.58%). Because of this high calcium carbonate content, Bay of Quinte sediments have a very good buffering capacity to compensate for any low pH water input, such as acid rain (Damiani and Thomas 1974).

Sediments of the Bay of Quinte, and in particular the upper bay, were found to be more reduced than those of Lake Ontario. Such conditions are most likely related to the high organic content of the bay's sediments compared to those of Lake Ontario. Higher organic contents are associated with fine grained sediment. Extremely high values (i.e., >15%) were found in Muscote Bay and along the southern shore of the upper bay towards Telegraph Narrows. The presence of fibrous plant material in sediment samples suggested that the organic matter is most likely derived from the abundant vegetation in the nearby marshes. Sedimentation rates of detritus measured in 1970's showed that up to 34% of the settling material was organic (Johnson and Brinkhurst, 1971).

Sedimentation rates based on measurement of ^{210}Pb , ^{137}Cs and ^{226}Ra at locations near the Trent River mouth, the centre of the upper bay and at Glenora were estimated to be 1.8 cm/year, 0.1 cm/year and 0.8 cm/year, respectively (Joshi and Fox, 1985). The rates near the mouth of the Trent River and at Glenora were significantly higher than those estimated for Lake Ontario (between 0.02 cm/year and 0.11 cm/year). It was found that post-depositional redistribution of the sediment by physical mixing is an important process in the Bay of Quinte, in particular in the upper bay.

Overall energy levels in the upper bay are higher than observed in deeper water lakes, and accounts for the coarser sediment (silt) and transportation of the fine material eastward.

3.3.3 Quality

Over the years, the increase in population, industrial and agricultural activities in the Bay of Quinte's watershed has affected the quality of the system's sediments. While a number of studies have been undertaken on sediment quality, very few locations have been sampled in successive years and most of the sampling has been in tributary or river mouth areas. A literature review on the quality of Bay of Quinte surficial sediments and an assessment of the environmental significance of persistence toxic contaminants was conducted in 1987. Evaluations were made primarily in relation to existing provincial criteria for open water disposal of dredged spoils, and to "background" levels for contaminants in pre-industrial sediment harbour areas (Table 22). Information and data for surficial sediment analyses was available from:

- . the mouth of the Trent River and Bay of Quinte at Trenton in 1973-1974, 1982 and 1985;
- . the mouth of the Moira River and Bay of Quinte at Belleville in 1973, 1977, 1982, and 1985;
- . the mouth of the Napanee River in 1973;
- . from the Bay of Quinte proper in the general vicinity of Belleville, Trenton, Deseronto, and Picton in 1982;
- . in the Long Reach area in 1977, 1978 and 1980.

A number of heavy metals exceeded the provincial open water disposal of dredged sediments guidelines for heavy metals.

- . copper - the Provincial Open Water Disposal of Dredged Sediments Guidelines for copper (i.e., 25 ug/g) has been exceeded in sediments in

the Bay of Quinte at Trenton, Belleville, Deseronto and Picton. The maximum copper concentration detected at each location was 50 ug/g, 95 ug/g, 40 ug/g and 45 ug/g respectively.

- . zinc - the provincial guideline for zinc (i.e., 100 ug/g) has been exceeded at Trenton, Belleville, Deseronto and Picton. Maximum zinc concentrations measured in sediment samples were 150 ug/g, 400 ug/g, 150 ug/g and 125 ug/g respectively.
- . lead - lead concentrations in sediments have exceeded the provincial guideline of 50 ug/g at Trenton, Belleville, Deseronto and Picton. Maximum lead concentrations detected were 110 ug/g, 150 ug/g, 100 ug/g and 110 ug/g respectively.
- . nickel - the provincial guideline for nickel (i.e., 25 ug/g) has been exceeded at Belleville (i.e., maximum concentration measured 42 ug/g), Deseronto (i.e., maximum concentration measured 40 ug/g) and Picton (i.e., maximum concentration measured 68 ug/g).
- . cadmium - concentrations in Bay of Quinte sediments at Belleville and, on occasion, at Trenton and Deseronto have exceeded the provincial guideline (i.e., 1 ug/g). The maximum cadmium concentrations were 4 ug/g at Belleville, 2 ug/g at Trenton and 1.5 ug/g at Deseronto
- . chromium - the provincial guideline for chromium (i.e., 25 ug/g) was exceeded at Trenton (i.e., maximum concentration measured 90 ug/g), Belleville (i.e., maximum concentration measured 80 ug/g) and Picton (i.e., maximum concentration measured 75 ug/g).
- . mercury - the provincial guideline for mercury (i.e., 0.3 ug/g) was exceeded in Bay of Quinte sediments at Trenton, Belleville and Deseronto. The maximum concentration found at each site was 0.7 ug/g, 0.8 ug/g and 0.4 ug/g respectively. At Picton, the maximum concentration

of mercury measured was 0.3 mg/g - the provincial guideline.

- . arsenic - arsenic was found at concentrations in excess of the provincial guideline (i.e., 8 ug/g) in Bay of Quinte sediments at Belleville, Deseronto and Picton. Maximum concentrations measured at each site were 28 ug/g, 19 ug/g and 12 ug/g respectively.

PCB concentrations in Bay of Quinte sediments have exceeded the Provincial Open Water Disposal of Dredged Sediments Guidelines (0.05 ug/g) at Trenton, Belleville, Deseronto and Picton. Maximum concentrations were 0.3 ug/g at Trenton and Belleville, 0.3 ug/g at Deseronto, and 0.2 ug/g at Picton.

"Background" or pre-industrial sediment criteria may be more appropriate for assessing the environmental significance of heavy metals and persistent toxic contaminants than open water dredge disposal criteria. With the exception of lead, pre-industrial background levels in depositional areas of Lake Ontario are higher than the somewhat arbitrary open water dredge disposal guidelines (Table 23). Comparison of contaminant concentrations with these "background" criteria indicated that:

- . lead levels exceeded background concentrations at all locations;
- . zinc concentrations were higher than background in all samples, except those collected in 1979 from Long Reach;
- . cadmium exceeded background in some samples on the Trent River and Moira River and in the upper bay in the vicinity of Belleville;
- . nickel levels exceeded background levels in the lower bay near Picton, south of Belleville and in Long Reach;
- . mercury levels were higher than background concentrations in the upper bay at Belleville; and
- . PCB levels exceeded background sediment concentrations in some of the samples in which dredge disposal guidelines were exceeded.

As well, high phosphorus concentrations have been found in the surface layers

of sediments. Under certain conditions, this sediment-associated phosphorus can be released into the overlying water, thereby supporting additional algal growth. Heavy metals and persistent organic contaminants can also be released under specific environmental conditions.

3.4 PHYTOPLANKTON

3.4.1 Quantitative Aspects

The phytoplankton of the Bay of Quinte has been monitored in the upper, middle, and lower bays since 1972. Data are also available from analyses of raw (untreated) samples collected at the Belleville water treatment plant intake.

During the pre-phosphorus control period (i.e., 1972 to 1977), maximum phytoplankton biomass values exceeding $30 \text{ mm}^3/\text{L}$ were measured in the euphotic zone, and values of 15,000 to 20,000 ASU/mL in the Belleville intake samples were common, indicating a highly productive, eutrophic system.

In the immediate post-phosphorus control period of 1978-1983, the May to October average phytoplankton biomass in the upper bay was reduced to 37% (i.e., $8.2 \text{ mm}^3/\text{L}$) of the pre-phosphorus control average of $13.1 \text{ mm}^3/\text{L}$ (Figure 26 and Table 28). The yield of phytoplankton per unit total phosphorus during both periods was significantly lower than those in other areas of the Great Lakes (Figure 27). However, in 1984 and 1985, there was a well-defined trend to much higher phytoplankton biomass in the upper bay, both in samples taken at the Belleville water treatment plant and in those collected as part of Project Quinte. The 1985 May to October average of $13.3 \text{ mm}^3/\text{L}$ in the upper bay is comparable to values recorded during the pre-phosphorus removal period of 1972-1977. In contrast, the May to October total phosphorus concentrations changed little between 1978 and 1983 (Figure 26).

In 1986 and 1987, phytoplankton biomass declined dramatically (i.e., $6.7 \text{ mm}^3/\text{L}$ and $9.0 \text{ mm}^3/\text{L}$), as did average total phosphorus concentrations in the upper bay (i.e., 33 ug/L). In fact, the 1986 average biomass was similar to average levels found for 1978 to 1983 in the upper bay (Table 29). As well, phytoplankton counts at the Belleville water treatment plant confirmed a return to lower algal densities throughout the upper bay (i.e., a

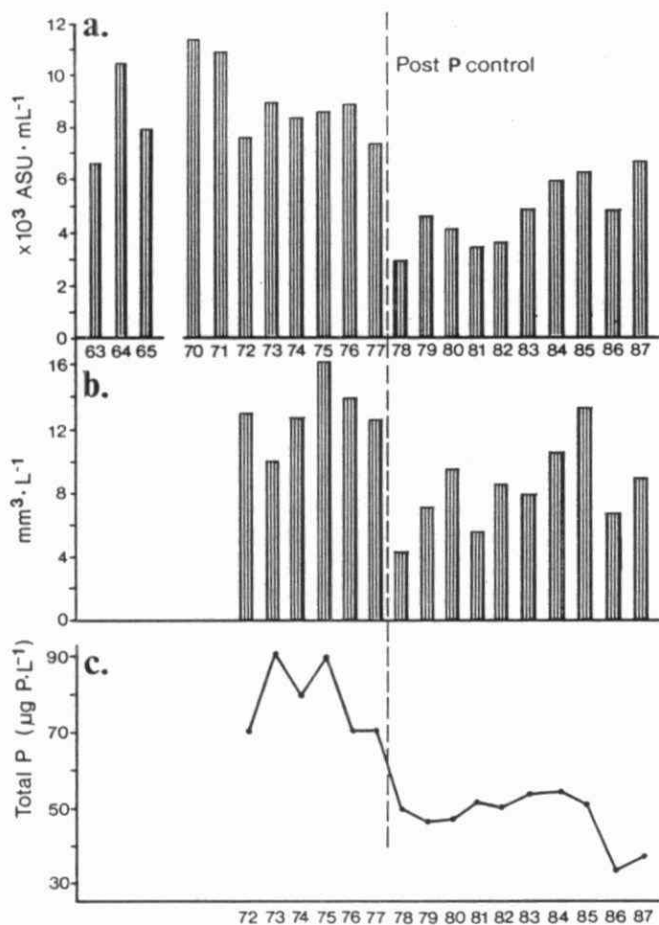


Figure 26. Average May to October densities of total phytoplankton in samples collected through the Belleville water treatment plant intake (a); at Station B in the upper Bay of Quinte (b); and total phosphorus concentrations over the same time period at Station B (c) (from Nicholls and Hurley, 1989).

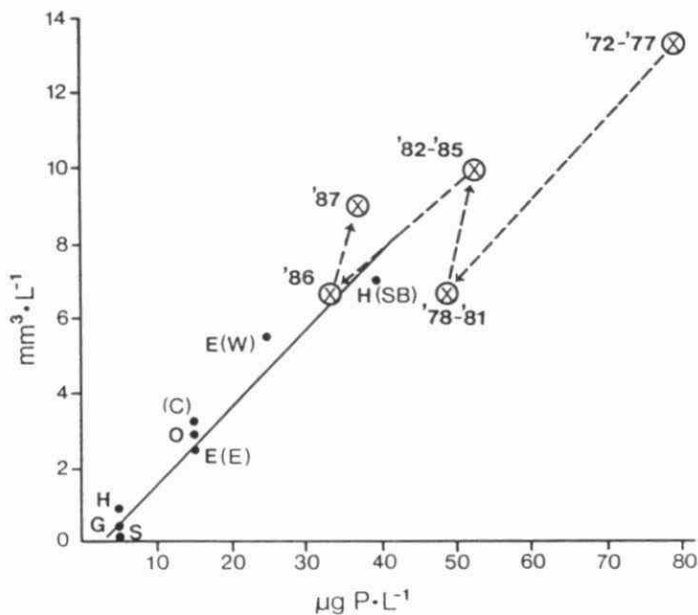


Figure 27. Changes in May to October phytoplankton biomass (mm^3/L) and total phosphorus concentrations ($\mu\text{g}/\text{L}$) in the upper Bay of Quinte, 1972-1987. Also shown are average values for other Great Lakes, keyed as follows: H(SB) = Saginaw Bay of Lake Huron; E(W), E(C) and E(E) = Lake Erie, western, central, and eastern basins respectively; O = Lake Ontario; H = Lake Huron; G = Georgian Bay; S = Lake Superior (from Nicholls and Hurley, 1989).

Table 28. Average phytoplankton density (total cell volume, cubic mm/L in the Bay of Quinte with comparisons of pre- and post-phosphorus control periods (May-October averages).

Year	Upper Bay	Middle Bay	Lower Bay
1972	13.1	8.4	3.3
1973	10.1	7.1	2.1
1974	12.7	7.8	1.9
1975	16.1	9.8	2.3
1976	14.0	10.9	3.0
1977	12.5	8.3	2.3 pre-P control
1978	4.3	4.2	1.8 post-P control
1979	7.1	4.7	0.9
1980	9.4	6.0	1.8
1981	5.5	5.4	1.3
1982	8.5	8.5	1.1
1983	7.4	9.9	1.5
1984	10.5	9.1	1.9
1985	13.3	5.5	1.3
1986	6.7	6.9	1.4
1987	9.0	7.2	1.7
Pre-P control 1972-77	13.1	8.7	2.5
Post-P control 1978-87-	8.2	6.7	1.4
% reduction	37.0	23.0	42.0

All results are arithmetic means of weekly analysis (May-October) except:

- 1) 1972, when samples were analyzed approximately monthly; and
- 2) 1978-1981 in the lower bay and 1982 in the upper bay when samples were pooled before analysis; and
- 3) 1983-1987 when samples from all stations were collected bi-weekly and pooled prior to analysis.

Table 29. Summary of May-October average phytoplankton as a percentage of total bio-volume (dominant algal classes) in the upper bay, 1972-1985.

	Percentage of Total					
	Cyano- phyceae	Dino- phyceae	Crypto- phyceae	Chryso- phyceae	Chloro- phyceae	Bacillario- phyceae
1972	17	3	3	<1	4	73
1973	20	6	4	1	3	66
1974	11	4	2	<1	2	82
1975	16	5	3	1	7	68
1976	22	1	3	1	4	70
1977	20	4	4	<1	6	65
1978	17	4	4	2	6	67
1979	27	4	3	<1	3	62
1980	21	2	6	2	4	65
1981	34	1	3	1	4	51
1982	13	1	2	<1	2	81
1983	21	<1	2	2	4	70
1984	39	1	3	1	2	54
1985	17	1	2	1	2	77

reduction of 24% from 1985). An average biomass of $6.9 \text{ mm}^3/\text{L}$ was found in the middle bay in 1986, which was lower than any average value recorded prior to 1978, but higher than the 1985 average of $5.5 \text{ mm}^3/\text{L}$. The 1986 average of $1.4 \text{ mm}^3/\text{L}$ in the lower bay was similar to many of the post 1977 values at this location.

3.4.2 Qualitative Aspects

The Bay of Quinte contains over 300 planktonic algal species, several are rare reportings from other parts of the world.

No dramatic changes have occurred in the phytoplankton composition of the upper bay throughout the years of Project Quinte. The May-October periods continue to be dominated by diatoms and blue-green algae. Total diatom biomass has been about 2-4 times greater than the blue-green biomass. The two groups combined provide in excess of 85% of total phytoplankton biomass (Table 27). As in earlier years, the dominant diatoms continue to be Melosira spp. (mainly M. granulata and M. ambigua). The average 1985 Melosira biomass ($9.5 \text{ mm}^3/\text{L}$) was higher than values recorded for the May to October periods of all previous years (Figure 12). Although much less dominant over the years, Stephanodiscus spp. has not increased (Figure 12). In this regard, the average biomass for Stephanodiscus spp. during 1978 to 1985 ($0.33 \text{ mm}^3/\text{L}$) was significantly less than the average ($1.14 \text{ mm}^3/\text{L}$) recorded for the pre-phosphorus control period of 1972-1977.

The highest silicate levels were found in 1978 and 1979 immediately following phosphorus loading reductions, although average concentrations have declined in recent years with the increased prevalence of Melosira spp. (Figure 12).

Since 1972, the nitrogen fixing blue-green species Anabaena spp. and Aphanizomenon spp. comprised between 54% (1975) and 75% (1981) of the total blue-green algal biomass. The lowest combined biomass of these two genera was found during 1978, the first year following the implementation of

phosphorus removal controls; the highest was in 1984 (Figure 13). Despite the steady increase in N/P in the upper bay in recent years, the contribution of nitrogen fixing blue-green algae (Anabaena spp. and Aphanizomenon spp.) to the total phytoplankton has not changed significantly, averaging 13.5% and 20% of the total phytoplankton biomass for the pre- (1972-1977) and post- (1978-1986) phosphorus control periods respectively.

The absence of any changes in species composition, despite the four-fold range in total biomass over the 16-year period, is one of the most surprising findings of Project Quinte. Based on the work of Tilman (1981), Smith (1983) and Sell et al. (1984), shifts in dominance between blue-green algae and diatoms should have occurred in the Bay of Quinte. However, as noted above, the upper bay continues to be dominated by a number of species of Stephanodiscus, Melosira, Anabaena and Aphanizomenon, of which the mid-summer populations of M. granulata and M. ambigua are the most important. The proportion of the total phytoplankton contributed by nitrogen-fixing Anabaena and Aphanizomenon has actually increased, while nitrogen to phosphorus ratios have increased from about 10 in the mid-1970s to 22 by 1987. As noted by Nicholls and Hurley (1989), the "critical threshold" concept of Smith (1983) may be quite important in the Bay of Quinte and dramatic proportional declines in Anabaena and Aphanizomenon may not occur until N/P values approach 30.

3.5 ZOOPLANKTON

Zooplankton are small animals in the aquatic food chain which resemble tiny crustaceans and feed on phytoplankton. Cooley et al. (1986) examined zooplanktonic communities between 1975 and 1983 to quantify responses to anticipated changes in the bay's trophic status. The following results are summarized from Cooley et al. (1986).

1. Zooplanktonic communities in the upper bay, middle bay, and lower bay were dominated by cladoceran species including Eubosmina coregoni, Bosmina longirostris and Chydorus sphaerieus (Table 30). These species represented 80% or more of all the cladocerans present on all occasions and locations. If Daphnia retrocurva, Ceriodaphnia lacustris and Diaphanosoma birgei are included in the count, the figure is closer to 99%.
2. Standing crop data, expressed as seasonal mean biomass averaged over the entire sampling season (Figure 28) showed:
 - the dominance of B. longirostris and E. coregoni;
 - the decreasing proportional abundance of cladocerans going from the upper bay to the lower bay;
 - the increasing proportional abundance of cyclopoids going from the lower bay to the upper bay;
 - no obvious changes in seasonal mean biomass between the two pre-treatment years and any of the five post-treatment years; and
 - a definite gradient of lower overall seasonal mean biomass going from the shallower, enriched upper bay to the deeper, moderately enriched lower bay.
3. E. coregoni, B. longirostris and C. sphaericus varied in abundance from year to year (Figure 28). B. longirostris was dominant from May into August, at which time, another species may or may not have replaced it. In 1982, this species dominated all samples through most of August. In contrast, the species composition of the three numerical dominants has

Table 30. Relative abundance of zooplankton species found in the Bay of Quinte, 1975-1983. Numerical abundance code is as follows: 1-dominant; 2-common; 3-rare or absent in some years. All data are from Cooley et al. (1986).

Species	Relative abundance
Cladocerans	
<u>Bosmina longirostris</u>	1
<u>Eubosmina coregoni</u>	1
<u>D. retrocurva</u>	1-2
<u>D. longiremis</u>	2
<u>D. galeata mendotae</u>	2
<u>D. pulex</u>	2
<u>D. ambigua</u>	3
<u>D. catawba</u>	3
<u>Ceriodaphnia lacustris</u>	1-2
<u>C. quadrangula</u>	3
<u>C. sp.</u>	3
<u>Chydorus sphaericus</u>	1
<u>Diaphanosoma birgei</u>	1-2
<u>D. sp.</u>	3
<u>Holopedium gibberum</u>	2-3
<u>Alona guttata</u>	2
<u>Sida crystallina</u>	3
<u>Polyphemus pediculus</u>	3
<u>Leptodora kindtii</u>	2
Cyclopoids	
<u>Cyclops bicusidatus thomasi</u>	1
<u>C. vernalis</u>	2-3
<u>C. scutifer</u>	3
<u>Tropocyclops prasinus mexicanus</u>	1
<u>Mesocyclops edax</u>	1
<u>Eucyclops agilis</u>	2
<u>E. sporatus</u>	3
Calanoids	
<u>Limnocalanus macrurus</u>	2-3 ^a
<u>Diaptomus sicilis</u>	2-3 ^a
<u>D. orogonensis</u>	2
<u>D. siciloides</u>	2
<u>D. minutus</u>	2
<u>D. ashlandii</u>	2-3
<u>Eurytemora affinis</u>	2
<u>Epischura lacustris</u>	2-3

^aLower bay only.

(a) BELLEVILLE

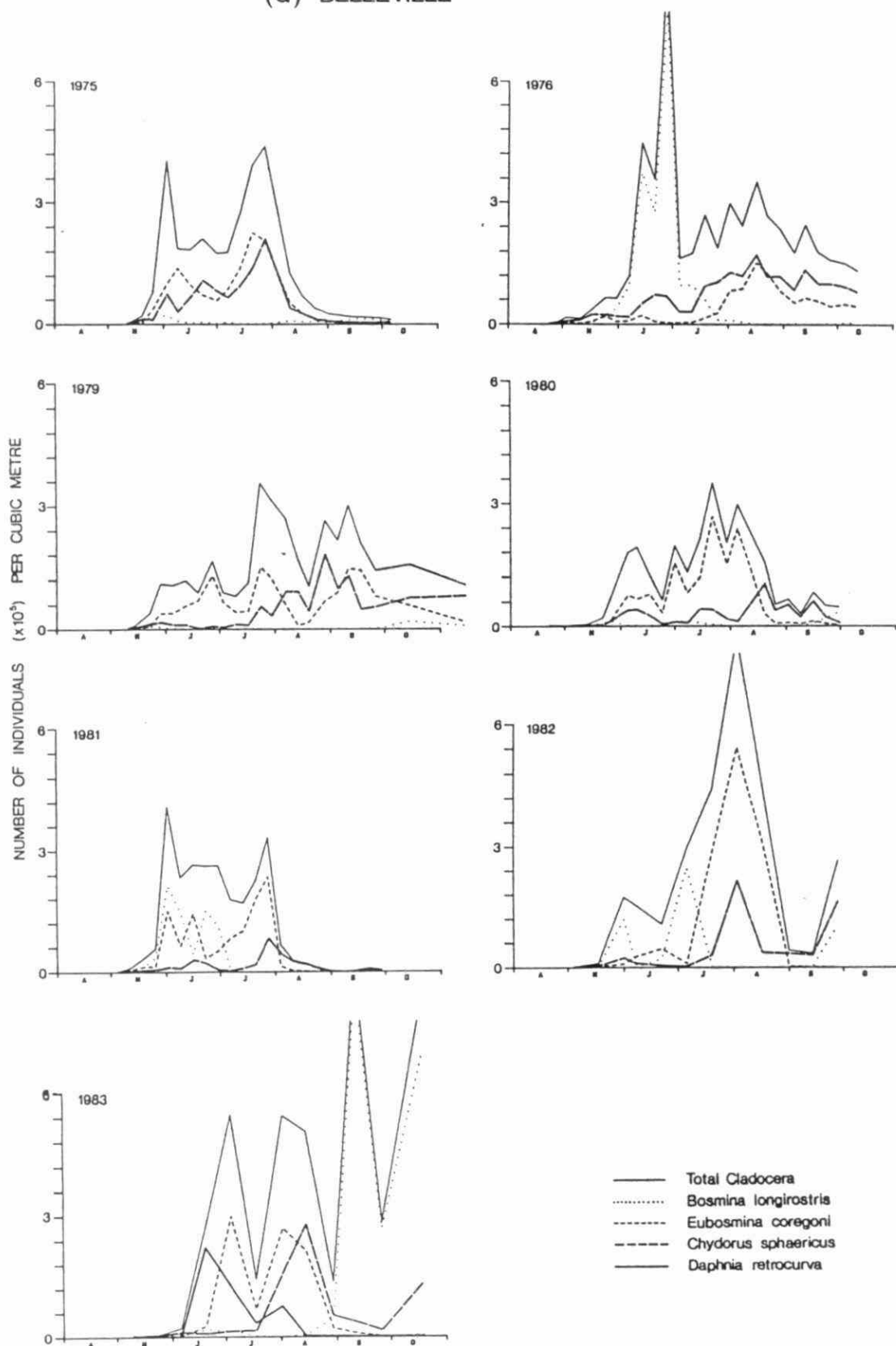


Figure 28. Population dynamics for major macrozooplankton species at (a) Belleville and (b) Conway in the Bay of Quinte. *Daphnia retrocurva* is included at Belleville for 1983 only. These curves have been plotted using "unsmoothed" data (from Cooley et al. 1986).

(b) CONWAY

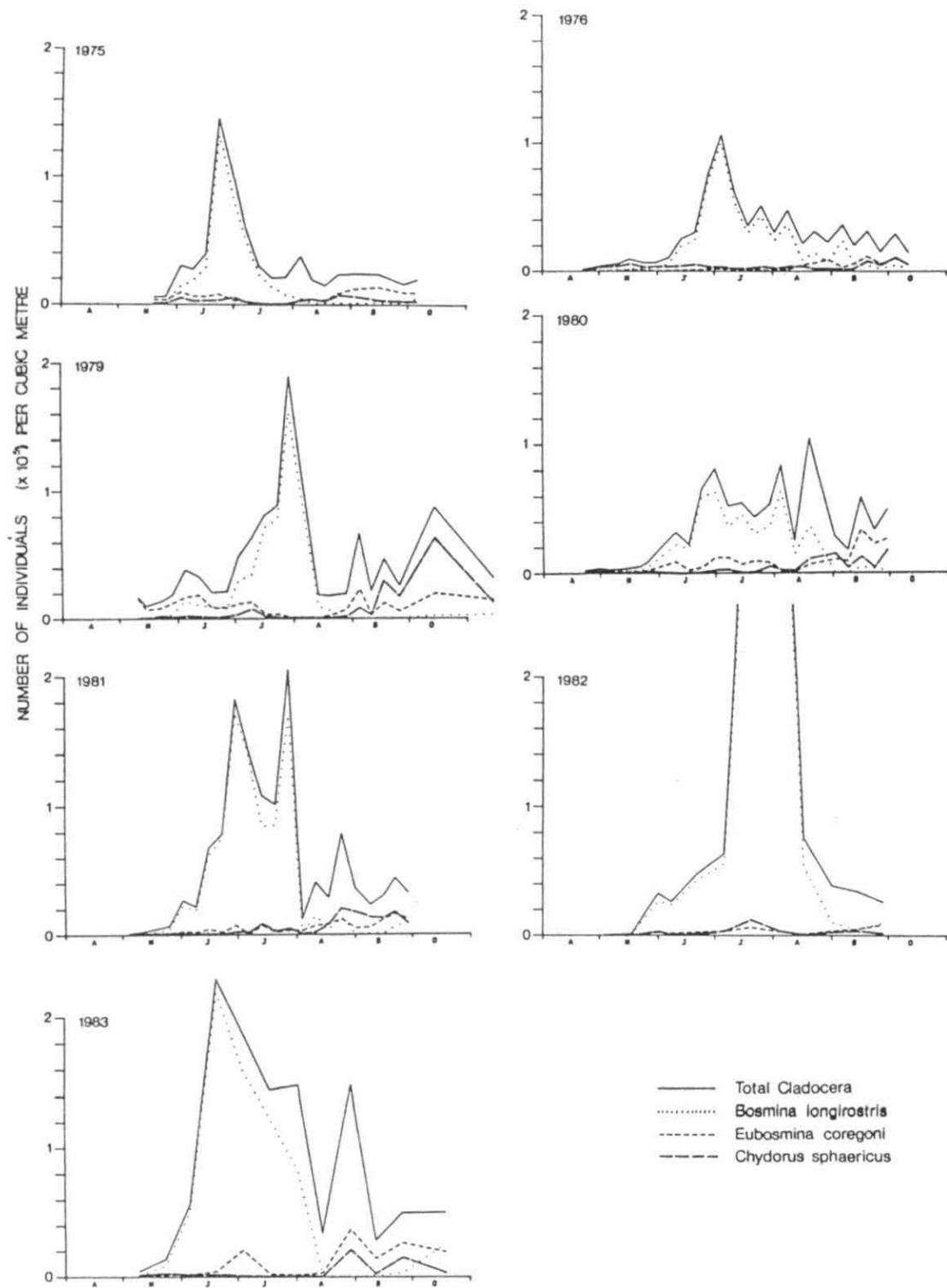


Figure 28. (continued)

been more variable in the upper bay. In 1976 and 1988, B. longirostris dominated the species composition in early summer and late fall respectively. Over three of the other five years, while common, it was a minor contributor to the overall cladoceran abundance, and in 1981 and 1982, B. longirostris was co-dominant with E. coregoni.

5. C. sphaericus was common throughout most of the year including winter. Its abundance peaked in July and August in the upper bay, and slightly later in the cooler lower bay.
6. In 1983, D. retrocurva assumed a numerical importance unprecedented in any previous year throughout the bay; in June, it was the dominant cladoceran. Following this peak, its numbers decreased rapidly, so that by mid-August it was a minor constituent of the community. Even with this resurgence, its mean daily abundance was only slightly higher in 1983 than in 1979 and 1982.
7. Daphnia galeata mendotae appears to have responded quite positively to phosphorus controls at local sewage treatment plants (Table 31). It has increased in abundance about 15 and 35 times at Belleville and Napanee, respectively. The smaller increases apparent in the lower bay likely resulted from increases in recruitment from upper bay waters.

Cooley et al. (1986) explained that lower overall densities of zooplankton and changes in species composition were expected to occur as a result of lower phosphorus loadings. However, by 1983, these trends had not materialized. For example, lower densities of C. sphaericus should have occurred in the upper bay. This species is a classical indicator of cultural enrichment, and tends to peak when blue-green algae are abundant. As noted in Section 3.5.2, blue-green algae are still prolific in the Bay of Quinte. It is not surprising therefore, that C. sphaericus has not declined since the introduction of phosphorus control measures at local sewage treatment plants.

The apparent resurgence of D. galeata mendotae in the upper bay following

Table 31. Mean seasonal abundance (numbers per m³) of Daphnia galeata mendotae in the Bay of Quinte (reproduced from Cooley et al. 1986).

Location	Pre-treatment		Post-treatment				
	1975	1976	1979	1980	1981	1982	1983
Upper bay	286	3	513	4,356	813	5,454	2,179
Middle bay	44	51	187	2,295	560	-	-
Lower bay	79	3	315	104	25	41	247

phosphorus control was unexpected. This species is large in size in comparison to other zooplankters and should have experienced heavy predation. The appearance of D. galeata mendotae may be an initial sign of a reduced planktivore population owing to increased predation by walleye. While contributions of this species to the overall zooplanktonic community are small and perhaps tenuous, its presence may be an early indication of a better balance in the structure of the upper bay's biological community.

3.6 BENTHIC MACROINVERTEBRATES

3.6.1 Data Base

Benthic samples have been collected periodically over a 19 year span from 1966 to 1984 (1966 to 1968, 1972, 1977, 1982 to 1984) from four index stations, and a maximum of 52 transect stations from the lower bay (Figure 29). The index stations were Big Bay in the upper bay, and Glenora and Conway in the lower bay and Lake Ontario. A total of 600 Ekman samples were collected during the 1966 to 1968 intensive survey, while 550 samples were collected between 1972 and 1984.

The mean numbers of individuals within five major macroinvertebrate groups at the index and transect stations are shown in Figures 30 and 31 respectively. An annotated list of species collected in the Bay of Quinte and adjacent Lake Ontario between 1966 and 1984 is presented in Appendix G.

3.6.2 Index Stations

Big Bay: Peak oligochaete numbers reached in 1977 were attributable to the increased numbers of Tubifex tubifex and Limnodrilus hoffmeisteri. After 1977, T. tubifex declined in numbers and Aulodrilus piqueti was not collected. Quistradilus multisetosus was present in samples in low numbers until 1982 when Spirosperma ferox first appeared and then increased in numbers from 1982 to 1984.

The chironomid abundance peaked in 1977 with 9 species present. Harnischia amachaerus, common in the 1967 to 1968 sampling period, was not collected after 1972. Procladius spp. numbers declined from 1972 to 1977, and continued to decline to 1984. Chironomus spp. numbers remained relatively uniform throughout the study except for C. plumosus which peaked in 1977. Polypedium sp. and Tanytarsus spp. numbers declined by 1977, and were not present in samples after 1982. Seven species were collected in 1966-68,

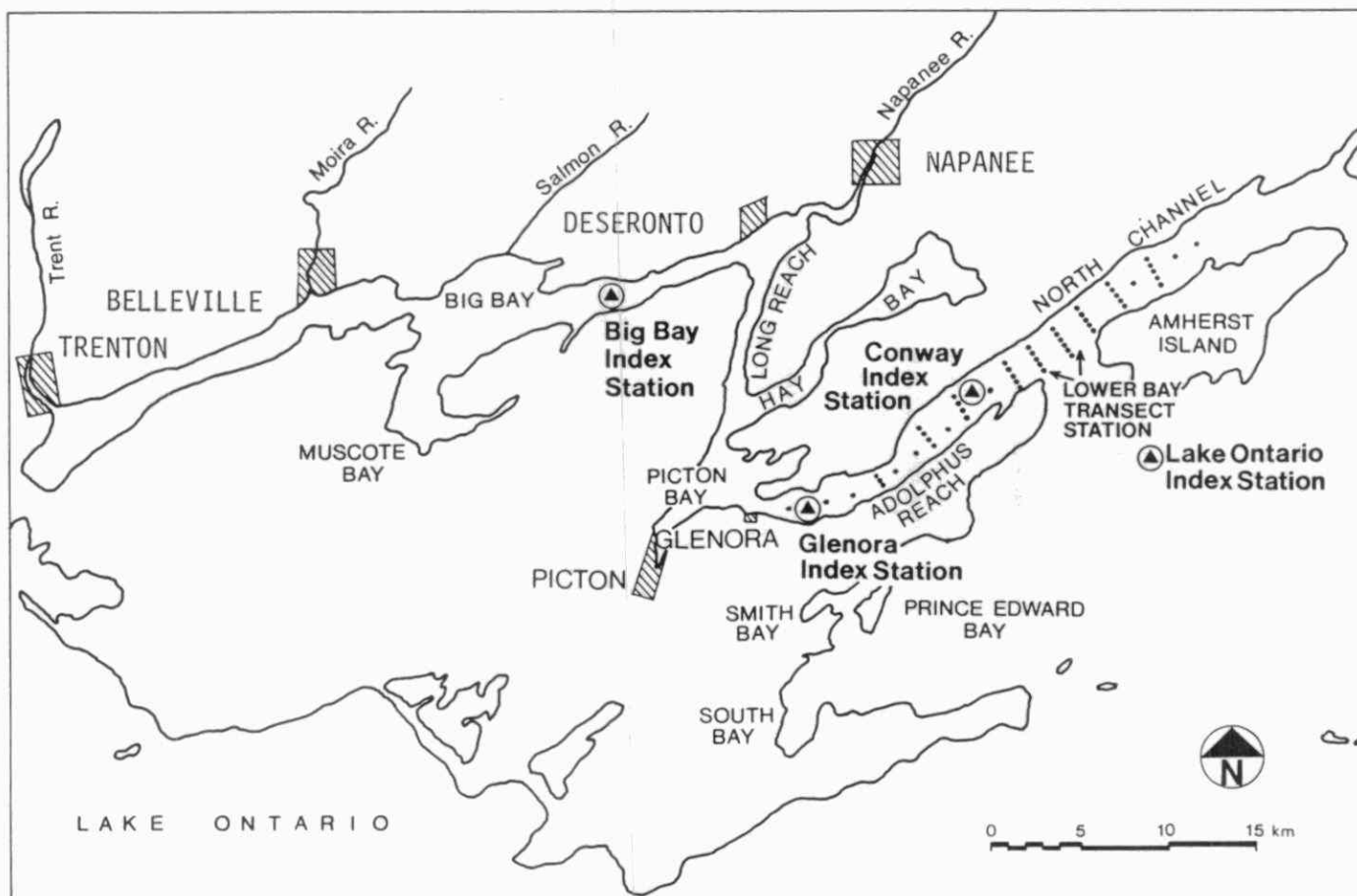


Figure 29. Locations of four index stations (Big Bay, Glenora, Conway and Lake Ontario) and 52 transect stations in the lower Bay of Quinte (Adolphus Reach and the mouth of the bay). For evaluation of benthic communities, the upper bay is from Belleville to Deseronto, the middle bay extends to Glenora, and the lower bay is from Glenora to Amherst Island (from Johnson and McNeil 1986).

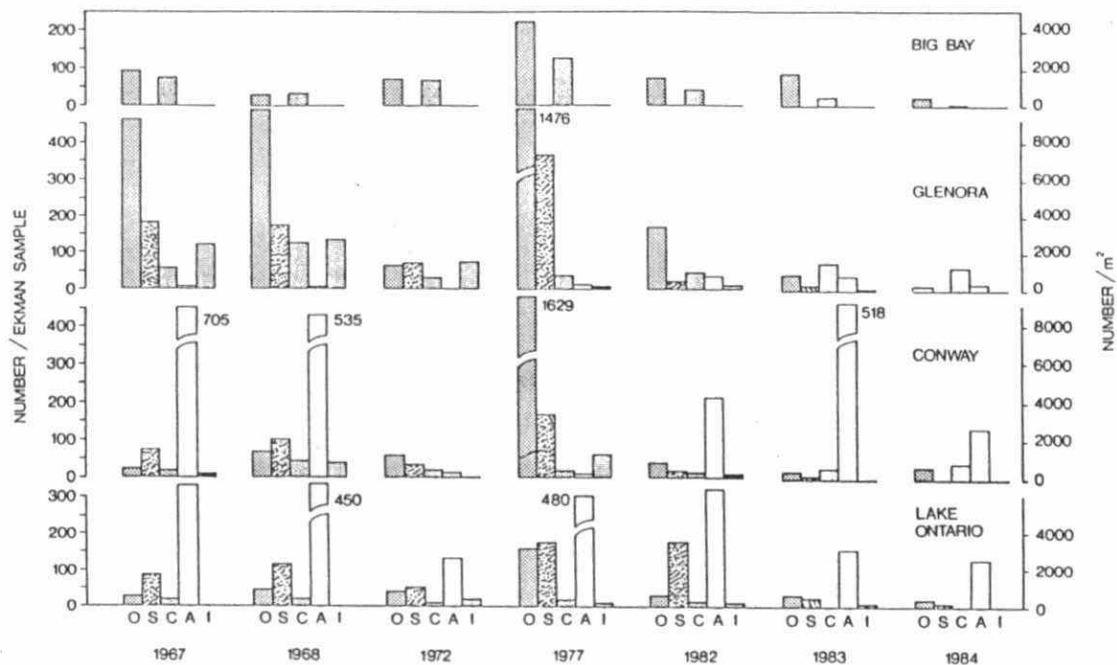


Figure 30. Mean numbers of individuals of major macroinvertebrate groups collected at index stations in August of 1967, 1968, 1972, 1977, 1982, 1983 and 1984. Six eckman samples comprise each data set. Groups are as follows: O, oligochaetes; S, sphaeriids; C, chironomids; A, amphipods; I, isopods (from Johnson and McNeil 1986).

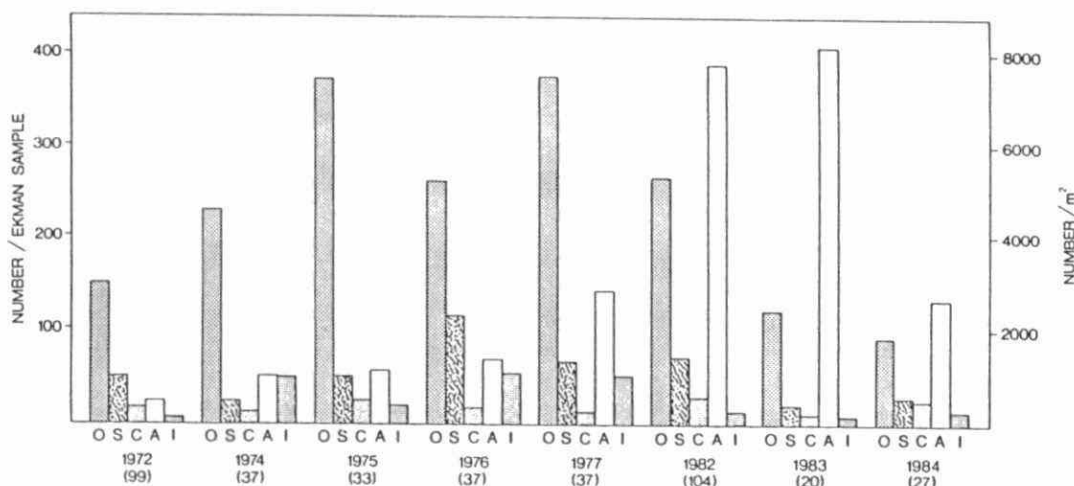


Figure 31. Mean numbers of individuals of major macroinvertebrate groups collected at transect stations in the lower bay during 1972-1984. The number of eckman samples for each data set is shown in parenthesis. Groups are as follows: O, oligochaetes; S, sphaeriids; C, chironomids; A, amphipods; I, isopods (from Johnson and McNeil 1986).

whereas only four were collected in 1984.

No sphaeriids were collected.

Glenora: Peak numbers of oligochaetes were reached in 1977 (i.e., $>28,000/m^2$) with 9 species. The dominant species were T. tubifex, L. hoffmeisteri, A. pluriseta, Q. multisetosus and Potamothrix vejdoskyi. P. bavaricus was not collected in the 1980's and A. pluriseta numbers declined in 1984. Oligochaete abundance declined to very low numbers (i.e., $60/m^2$) with only five species collected in 1984.

The chironomid community remained relatively stable throughout the study with three Chironomus species (i.e., C. anthracinus, C. plumosus, C. atritibia), Procladius spp., Chrytochironomus sp. and Tarytarsus spp. present in all years.

In the 1966 to 1968 sampling period, 12 sphaeriid species were collected. Sphaeriid numbers peaked in 1977 with 9 species, declined to 7 species in 1982 and 1983, with only one species (i.e., Pisidium casertanum) collected in 1984.

Pontoporeia hoyi numbers were scarce in 1966 to 1968 and not collected in 1977. By 1983, their numbers had increased rapidly and stabilized in 1985.

Conway: Peak numbers of oligochaetes were reached in 1977 with T. tubifex and L. hoffmeisteri the most common species found. The species composition at the end of the 1982 to 1984 sampling period was similar to that during the 1966 to 1968 period. However, the average mean numbers were lower in the 1980's than in the late 1960's. P. moldaviensis, P. vejdoskyi, S. ferox and Ilyodeilus templatoni were collected in the 1980's although they had not been collected in the 1970's.

Tanytarsus spp. was scarce at both the beginning and the end of the study period. Microspectra spp. numbers increased in the 1980's, while Tanytarsus

spp. numbers declined. Three Chironomus species were present in the 1966-68 collections, while only C. atritibia was collected in 1984. Procladius spp. numbers were uniform throughout the study except in the 1970's, when they declined to very low numbers.

In 1977, sphaeriid numbers peaked with nine species. By 1984, only four species were collected (i.e., P. casertanum, P. conventus, P. henslowanum, P. lilljeborgi).

The largest numbers of P. hoyi occurred in the 1966-68 sampling period (13,500/m²). By the 1970's, their numbers declined to 140/m², and then rebounded in the 1980's to over 10,000/m².

Lake Ontario: Oligochaete numbers peaked in 1977, but declined to scarce status by 1984. Only Stylodrilus heringianus, which was scarce in 1966-68 and not collected in the 1970's, reappeared and increased in the 1980's.

Throughout the study, the chironomid numbers remained low but stable. The community was dominated by Procladius spp., Microspectra sp. and Tanytarsus spp.

The sphaeriid community remained stable with P. casertanum, P. conventus and P. lilljeborgi as principal species.

P. hoyi numbers remained abundant from 1966 to 1984.

3.6.3 Transect Stations (Lower Bay)

Peak numbers of oligochaetes were reached in 1975 and 1977, with T. tubifex, L. hoffmeisteri and P. vejovskyi as dominant species. These species then declined in numbers to less than 2,000/m² in 1984. A. pluriseta was common only in 1975 to 1977, being absent before 1975 and again in 1984. In the 1980's, only S. ferox and S. heringianus increased in numbers.

Procladius spp. numbers were lowest from 1974 to 1977, but recovered in the 1980's. Chironomus anthracinus and C. plumosus declined through the 1970's to rare status, and only C. atritibia increased in the 1980's. The distribution of Microspectra sp. and Tanytarsus spp. tended to be inversely related.

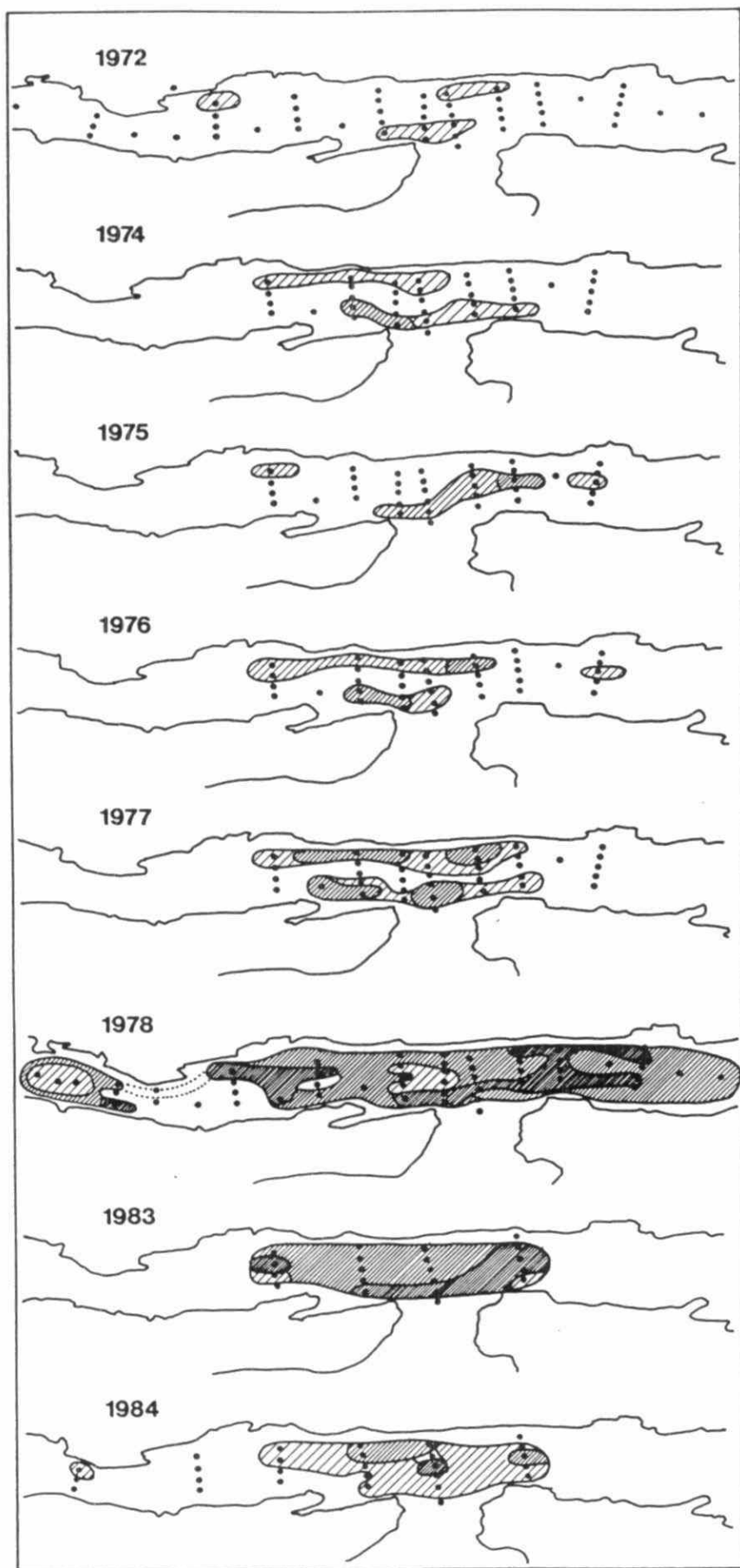
Sphaeriid abundance declined in the 1980's, with P. casertanum as the commonest species. Only P. lilljeborgi and Sphaerium nitidum maintained their numbers throughout the study period.

P. hoyi showed the most significant change throughout the sampling period. Their numbers steadily increased to reach peak values in 1982 (Figure 32).

3.6.4 Relevancy of Findings

Quantitative aspects: During the 1967 to 1968 sampling period, 128 taxa were collected, compared with 87 in 1972 to 1977 and 54 in 1982 to 1984. Significant decreases in numbers and taxa of oligochaetes, chironomids and sphaeriids in the 1980's are indicative of declining macroinvertebrate standing stocks and probably production, likely attributable to phosphorus reduction and declining primary production.

Species trends and water quality: Several significant changes in species composition have occurred which are indicative of water quality improvements (Johnson and McNeil 1986). The number of pollution-tolerant oligochaetes such as L. hoffmeisteri, T. tubifex and Q. multisetosus, has declined, and the pollution intolerant species S. heringianus in the lower bay has increased. Also, A. pluriseta and P. vej dovskyi common in a state of advanced eutrophication (Brinkhurst, et al., 1968) declined in the 1980's. Other Potamothrix and Aulodrilus species declined in numbers or disappeared in the 1980's. In upper bay, A. piqueti was absent in samples after 1977, and at Glenora in the lower bay, P. bavaricus was not collected after 1980, and A. pluriseta declined in numbers in 1984. However, at Conway both P. vej dovskyi and P. moldaviensis, although absent in 1970's samples, were



Pontoporeia hoyi

 $> 1,000 / \text{m}^2$

 $> 5,000 / \text{m}^2$

 $> 10,000 / \text{m}^2$

Figure 32. Abundance of *Pontoporeia hoyi* in August transect station samples from the lower bay. A total of 52 stations were sampled in 1972 and 1982 whereas 20-37 stations were sampled for other years (from Johnson and McNeil 1986).

collected in the 1980s.

The chironomid community, although relatively stable throughout the study period, also showed decreasing numbers of pollution-tolerant species such as C. anthracinus and C. plumosus, and an increase in C. atritibia, a species less tolerant of eutrophic conditions. The other dominant chironomids (Tanytarsus, Microseectra and Procladius) consisted of several species, and it is difficult to interpret water quality in terms of the absence or presence of genera.

Sphaeriid numbers, generally of all species, declined throughout the study period with P. casertanum being the most common species. According to Johnson and McNeil (1986), "...insufficient understanding of ecological requirements and considerable variability in numbers of the main species make interpretation of trends by species difficult. However, most species apparently were reduced in numbers as productivity of the bay declined."

Fish - macroinvertebrate interactions: Johnson and McNeil (1986) indicated that the most significant change in benthic macroinvertebrate communities in the lower bay was probably the increase in numbers of P. hoyi, shown by the results of samples collected in 1972 through 1986 (Table 32 and Figure 32).

In 1972, it appeared that P. hoyi was on the brink of extinction because of worsening oxygen conditions in the lower bay, especially in deeper waters. However, strong evidence indicates that a large population of white perch maintained heavy predation pressure on P. hoyi (Hurley 1986a), and when the white perch collapsed in 1977, numbers of P. hoyi increased, and extended up the bay to Glenora, attaining levels typical of populations at comparable depths in eastern Lake Ontario (Figure 32). Johnson and McNeil (1986) dismissed the possibility that increased densities of P. hoyi occurred as a result of improved deep-water oxygen conditions after phosphorus input reductions. Minns and Johnson (1986) concluded that there was no obvious difference in oxygen concentrations in the lower bay hypolimnion between years before and years following phosphorus reduction. Because numbers of

Table 32. Mean numbers of Pontoporeia hoyi, Gammarus fasciatus, and Caecidotea racovitzai per square meter in transect surveys each August of eight years (standard errors in parentheses). All data are from Johnson and McNeil (1986).

Year	Species	Depth (m)			
		<25	25-35	36-45	>45
1972	<u>P. hoyi</u>	580(206)	720(348)	340(240)	80(62)
	<u>G. fasciatus</u>	68(10)	38(24)	14(6)	46(30)
	<u>C. racovitzai</u>	50(24)	100(16)	80(24)	74(16)
1974	<u>P. hoyi</u>	1100(294)	1560(848)	1760(1742)	60(34)
	<u>G. fasciatus</u>	26(140)	26(8)	0	2(2)
	<u>C. racovitzai</u>	504(200)	1926(502)	864(738)	752(368)
1975	<u>P. hoyi</u>	440(168)	1440(1070)	2440(2432)	500(188)
	<u>G. fasciatus</u>	50(18)	0	10(6)	88(62)
	<u>P. racovitzai</u>	622(204)	188(96)	244(106)	250(90)
1976	<u>P. hoyi</u>	1100(362)	2660(1530)	1420(1026)	940(582)
	<u>G. fasciatus</u>	120(38)	194(138)	14(8)	70(56)
	<u>P. racovitzai</u>	1498(392)	2566(1598)	466(184)	626(342)
1977	<u>P. hoyi</u>	2940(744)	7880(2748)	2100(1614)	900(682)
	<u>G. fasciatus</u>	14(6)	44(32)	20(12)	10(4)
	<u>P. racovitzai</u>	1096(348)	2016(770)	678(380)	694(194)
1982	<u>P. hoyi</u>	9600(1188)	8960(1240)	2960(826)	8260(1134)
	<u>G. fasciatus</u>	8(2)	24(10)	52(14)	74(46)
	<u>P. racovitzai</u>	90(18)	220(30)	700(166)	358(78)
1983	<u>P. hoyi</u>	6880(1418)	13900(920)	8120(898)	8360(3138)
	<u>G. fasciatus</u>	8(8)	0	6(6)	12(8)
	<u>P. racovitzai</u>	30(12)	760(700)	340(250)	336(262)
1984	<u>P. hoyi</u>	3060(696)	2140(1020)	1400(756)	3660(2382)
	<u>G. fasciatus</u>	14(10)	0	0	56(12)
	<u>C. racovitzai</u>	22(10)	632(260)	106(50)	896(352)

P. hoyi declined even in areas of high environmental suitability, and independent of deep water oxygen conditions, the hypothesis of suppression of P. hoyi by a large population of stunted white perch is highly plausible.

An increase in yellow perch occurred during the periods of 1977 to 1981, the same time that the white perch population was collapsing (Hurley 1986a). The diet of yellow perch includes considerably greater numbers of the amphipod Gammaras fasciatus than P. hoyi, presumably because G. fasciatus was more abundant in inshore environs than P. hoyi. (Yellow perch tend to inhabit inshore shallow waters.) While the sampling design of Johnson and McNeil (1986) did not extend into the shallower littoral zone of the lower bay, they speculated that the expansion of the yellow perch population reduced the supply of G. fasciatus. At the same time that P. hoyi was recovering after 1977, the isopod Caecidotea racovitzai was declining. Johnson and McNeil (1986) suggested that its decline might have related to the increase in fish species including yellow perch and/or to the decline in productivity in the bay.

Summary: Changes in benthic macroinvertebrates have included reductions in standing stocks and species shifts following the implementation of phosphorus removal controls at local sewage treatment plants. The changes generally have been the reverse of those observed under deteriorating water quality conditions. P. hoyi, all but extinct in the mid-1970s in the lower bay, has recovered after 1977 following the collapse of a white perch population. A coincident increase in yellow perch may have suppressed numbers of the amphipod G. fasciatus, and possibly the isopod C. racovitzai. Most of these findings indicate that past abatement actions have had a beneficial impact on water quality. Also, the changes suggest that an even healthier macroinvertebrate community can be expected with further abatement action.

3.7 MACROPHYTES (AQUATIC PLANTS)

The earliest recordings of aquatic plants in the Bay of Quinte are those of Macoun (1878 and 1883 to 1890); 37 species were reported, although some probably were not found on the shoreline.

In the early 1950s, the amount and distribution of shoreline aquatic vegetation had increased in response to increasing enrichment and, in part, to natural fluctuating water levels in the Great Lakes which improved habitat and facilitated expansion (Crowder and Bristow 1986). However, by the late 1960s, plant growths were on the decline while standing stocks of algae were increasing (Nicholls et al. 1988). The decrease in plant growth was attributed to the shading effects of phytoplankton which limited vascular plant growth to water depths of 2 m or less, and in part, to prolonged stable water levels which reduced overall productivity within the submerged wetland areas.

Crowder and Bristow (1986) investigated the composition and distribution of plant material between 1972 and 1982 to test the hypothesis: phosphorus control would decrease algal biomass, and in turn, increase water transparency, macrophyte distribution and abundance. The species found in five transects (i.e., southeast of Trenton, south of Belleville, through Big Bay, through Long Reach and east of Conway) are presented in Appendix H, with common names and records of previous occurrences also given. The following are highlights from that investigation.

1. Some plants which occurred in the Belleville area in the early 1880s were not encountered during the 1972 to 1982 investigations including Potamogeton gramineus, P. illinoensis, P. praelongus and Zannichellia palustris.
2. Cattail, although common across Canada, was not commonly found in the Bay of Quinte area.

3. As late as the 1950s, stands of wild rice were very abundant in the Bay of Quinte (Peters 1951). Substantial losses in wild rice beds have occurred since the 1950s in the Hay Bay and Rossmore to Belleville areas (Crowder and Bristow 1986). These areas are now dominated by cattail marshes.
4. Between 1972 and 1982, the dominant plant species were Eurasian milfoil, mud plantain, bushy pondweed, and water celery; all are found in enriched waters (Crowder et al. 1977a; Miller 1979).
5. Eurasian milfoil is an introduced species. It has extended its territory widely in North America during the 1960s and 1970s, and it tolerates both turbidity and pollution. Growth occurs early in the spring although peak biomass occurs five to ten years after its initial appearance. Accordingly, there is generally a decrease in species diversity as Eurasian milfoil increases its range - particularly Potamogeton - (Nichols and Mori 1971 and Bloomfield 1978). As noted, three species of Potamogeton growing near Belleville 100 years ago were not encountered in 1972 to 1982, and only six species were found on transects in the bay compared to 11 species found in nearby mesotrophic lakes (Crowder et al. 1977a and 1977b).
6. In 1979, weedbeds of the Bay of Quinte covered 4,701 ha: 627 ha of submerged and floating plant material; and, 4,074 ha of cattail marshes.
7. During the 1972 to 1982 period, the percent aquatic plant cover on transects in the Bay of Quinte was 22%. In comparison, Lake Ontario had 75% cover, and nearby inland mesotrophic lakes had 100% cover. The percent cover in the bay has increased in post-phosphorus years (1978 to 1989); however, the increases were not significant.
8. During the 1972 to 1982 period, the standing crop of aquatic macrophytes was low throughout the bay (i.e., 26 gm/m²). In nearby moderately enriched lakes, the standing crop biomass was 248 gm/m².

9. Species richness, a measure of diversity, in both submergent and emergent plants within the bay was low compared to richness in other mesotrophic lakes in the region. As well, no general improvement in richness occurred following the implementation of phosphorus control measures. Moreover, species richness in Hay Bay decreased (Bynoe 1979 and Percival 1979), likely as a result of increased agricultural runoff .
10. Using 28 g/m^2 as an estimate of mean standing crop for submergent plant biomass and a phosphate content value of 0.28% (Boyd 1970), the total phosphorus content for the standing crop was estimated to be 494 kg as total phosphorus. According to Crowder and Bristow (1986), most of the submerged biomass will be turned over annually, and the associated phosphorus made available to the ecosystem.

For emergent plants, the content of total phosphorus in the standing crop of 4,074 ha was calculated to be 89,891 kg (based on a measured phosphorus content of 1.47 mg/gm and a standing crop estimated at 1.5 kg/m^2 [Whigham et al. 1978 and Taylor and Crowder 1983]). The phosphorus is largely sequestered in rhizomes and therefore not available. Nonetheless, some of the nutrient content from this source is delivered to downstream Lake Ontario.

11. Regarding the hypothesis noted earlier on phosphorus loading reductions and anticipated improvements in aquatic macrophytes, Crowder and Bristow (1986) stated:

"Increasing nutrient levels presumably caused the increase in weed beds reported during the 1950s and early 1960s. When a hypereutrophic state was reached, decreased transparency of the water column, due to algal biomass, suppressed the macrophytes. In 1977, only 14% of the area of the Bay was occupied by submerged plants which did not grow below a depth of 2 m, except at Conway. At Conway the vegetated zone was 4 m in depth; had similar light conditions prevailed throughout the middle and upper Bay, 40% of its area could

have been occupied by macrophytes. This estimate, based on morphometry, should perhaps realistically be reduced to 30% to allow for shores exposed to waves or ice scouring (Forest et al. 1978 and Keddy 1983). Water transparency has increased as algal biomass has diminished during the post-phosphorus control period (Robinson 1986; Millard and Johnson 1986), so that the macrophytes might have been expected to recover. In our transects in the shallows, however, the expected increase in water transparency was not found, presumably because of suspended sediment. The macrophytes have not, therefore, been able to recolonize their former habitats in deeper water."

12. Over the past two years, anecdotal evidence has emerged which indicates a return of rooted aquatic plants in isolated areas of the bay (George Hammett and Adele Crowder, personal observation and A.D. Revill, unpublished manuscript).

In conclusion, the aquatic macrophyte community of the Bay of Quinte has not recovered as hypothesized. Rather, species diversity, territory and community structure are unchanged in spite of reduced phosphorus loads. Diversity and structure are low partly because of the continued presence of Eurasian milfoil and, partly because of sediment losses during the hypereutrophic years. However, over the last year or two, some anecdotal evidence suggests that of rooted aquatic plants are returning to some areas of the bay.

3.8 FISHERIES

Hurley and Christie (1977) described the pre-phosphorus control fish community of the Bay of Quinte. Large numbers of small-sized, or stunted fish having relatively short life spans and high reproductive potential characterized the bay. The authors hypothesized that the abundance of piscivores was a key factor in maintaining a balanced fish community (i.e., one or two species of planktivores or benthivores does not dominate the community). They hypothesized that eutrophic related stresses inhibited large piscivore competition; and, as a result, smaller, short-lived species proliferated.

However, as described by Hurley (1986b), phosphorus reductions in the Bay of Quinte and the effects of a severe winter changed the fish community. Walleye returned in the late 1970s, and with increased walleye predation on small-sized fish, coupled with a winter kill of white perch, the growth rate and abundance of white perch increased.

The information on fish species of the bay reported below are the results of netting undertaken between 1972 and 1987. The relationship between observed fish species and nutrient levels, weather anomalies, piscivore abundance, and commercial and sports harvest also are presented. Graphic trends are presented only for those species having a significant biomass, while information for other fish species is listed in various tables and Appendix I.

3.8.1 Relative Abundance and Distribution of Fish

The Bay of Quinte supports a diverse fish community of at least 65 known species (Appendix I). Most are associated with warm water, and are primarily found in nearshore zones that typically reach temperatures of 22°C to 25°C in mid-summer. Some cold water species, such as lake whitefish, lake herring and several salmonids, also live in the bay at certain times of the year.

Amiidae: Bowfin occurred in high numbers between 1975 and 1977 (Table 33). The largest populations were found in upper bay, and the smallest stocks were in the lower bay.

Clupeidae: Alewives generally have been the most abundant species in the bay (Tables 33 and 34). Alewife abundance at Hay Bay increased by a factor of 3 between the 1960s and the mid-1970s (Figure 33). Between 1972 and 1976, alewife were more abundant in the upper bay and middle bay than in the lower bay; after 1976, the reverse was the case (Table 33). Over the last few years, alewife populations appear to be declining throughout the bay, except in the lower bay. Hurley (1986b), hypothesized that increased predation by walleye after 1976 has reduced alewife numbers substantially.

The gizzard shad commonly was found in the upper bay (Tables 33 and 34); fewer numbers were caught in the middle bay and lower bay. Overall, the numbers of gizzard shad has decreased in the early 1980s relative to population densities in the mid-1970s.

Salmonidae: To 1940, lake herring and, to 1960, lake whitefish entered the Bay of Quinte to spawn (Christie 1973). However, rainbow smelt predation on lake herring, increased nutrient enrichment, subsequent poor water quality in the case of lake whitefish, and commercial exploitation in both cases collapsed these stocks. Remnant populations of both species are still present in the bay, although a modest resurgence of lake whitefish recently has been observed. According to Hurley (1986b), lake whitefish have "...originated from the small residual stock ... that persisted in the less eutrophied areas of the lower Trent River. There is evidence that lake whitefish originating from open Lake Ontario are also augmenting the bay stocks...".

As reported by Hurley (1986b), "...natural reproduction in rainbow trout and brown trout now enhances the population that was initially dependent on hatchery stocking. Current management initiatives have resulted in plantings of lake trout, coho and chinook salmon, and, to a lesser degree, splake. Natural reproduction within these species has not yet been demonstrated."

Table 33. Mean annual catch per unit of effort for standard experimental gillnet lifts from the upper, middle, and lower sections (UB, MB, and LB, respectively) of the Bay of Quinte. All data are from Hurley (1986).

Species	Location	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
Bowfin	UB	2.8	2.8	6.7	10.5	5.3	11.8	1.3	2.3	4.8	1.0	0.5	0.5
	MB	0.5	0.5	1.0	5.8	1.5	1.8	1.0	0.5	1.0	0.0	0.0	0.0
	LB	0.5	0.3	0.0	0.5	0.0	0.3	0.0	0.1	0.0	0.0	0.0	0.0
Alewife	UB	2019.2	3029.5	3872.5	2507.5	3110.5	348.5	923.7	1148.8	1004.7	311.0	558.0	1138.0
	MB	1176.8	2508.8	1099.5	1111.8	2872.5	1237.3	1224.8	2249.5	1368.0	512.0	925.5	639.0
	LB	376.3	2985.5	1124.8	818.5	1585.8	1229.8	2175.5	1630.8	2711.1	2561.5	2659.5	5337.5
Gizzard shad	UB	22.7	42.2	65.8	373.5	235.8	254.7	205.3	172.3	130.5	109.0	15.0	8.0
	MB	13.8	69.0	8.0	58.5	16.5	117.5	176.0	88.5	70.0	32.0	0.0	1.0
	LB	28.3	5.3	22.3	75.3	21.8	88.8	68.1	30.5	20.5	3.0	0.5	0.0
Rainbow smelt	UB	0.7	0.0	0.0	0.7	1.8	0.0	3.5	0.0	0.0	0.0	0.0	0.0
	MB	0.5	2.5	2.8	2.3	2.0	16.5	13.5	0.5	0.5	1.0	1.5	0.5
	LB	23.5	81.3	6.8	18.1	3.0	12.3	21.0	11.4	8.0	27.5	5.0	0.0
White sucker	UB	17.3	26.3	17.0	13.3	20.3	24.3	28.3	23.0	40.3	27.5	27.0	46.5
	MB	8.0	4.5	5.8	7.5	10.5	20.3	11.3	12.0	37.3	15.0	27.5	28.0
	LB	2.8	4.0	1.5	4.5	3.0	2.4	0.9	1.4	16.6	29.0	29.0	30.5
Brown bullhead	UB	23.5	45.5	90.7	89.8	81.0	111.2	116.2	64.8	88.0	47.0	40.0	16.5
	MB	18.5	25.0	22.3	98.8	56.3	155.8	71.3	22.8	39.3	21.5	1.5	2.5
	LB	5.0	0.8	2.8	2.1	0.5	1.1	0.9	0.1	0.3	0.0	0.0	0.0
Channel catfish	UB	5.8	6.5	18.3	4.2	3.8	4.3	14.0	17.2	21.7	14.0	7.5	13.5
	MB	1.0	0.3	0.0	0.5	0.5	0.5	4.5	5.0	1.5	1.0	0.0	0.0
	LB	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0
White perch	UB	1000.2	995.8	1501.2	807.3	792.7	1086.0	142.0	266.7	447.0	679.5	556.5	383.0
	MB	879.8	700.5	566.3	674.3	508.8	949.5	168.8	135.3	149.8	119.5	6.0	40.5
	LB	348.0	305.0	343.0	330.4	335.6	314.6	39.9	44.6	52.1	28.0	9.5	43.5
Smallmouth bass	UB	3.2	4.7	8.0	5.5	8.5	8.3	19.2	21.8	22.3	15.5	31.0	23.0
	MB	2.8	2.3	0.5	1.3	0.5	9.3	9.8	4.5	3.5	7.0	3.0	0.5
	LB	0.0	1.0	0.0	3.5	0.6	1.1	2.3	2.0	1.0	0.0	0.0	1.0
Other centrarchids	UB	2.2	0.9	2.0	1.1	1.3	2.5	15.8	6.8	10.2	2.0	3.5	2.0
	MB	1.3	1.3	0.8	1.5	0.8	1.6	2.1	1.6	2.3	0.0	0.0	0.0
	LB	32.1	16.1	9.1	22.9	10.7	14.9	21.7	13.6	8.1	14.5	21.5	34.5
Yellow perch	UB	277.7	238.7	340.8	189.3	367.5	333.0	829.5	643.8	580.3	449.5	146.0	219.0
	MB	394.5	252.3	186.8	294.0	307.0	319.5	681.0	550.5	652.5	603.0	464.0	519.0
	LB	436.8	415.8	470.0	669.8	454.9	479.8	965.5	790.4	892.1	921.5	1337.5	573.5
Walleye	UB	1.3	1.8	4.0	2.3	3.7	3.0	25.2	32.3	65.8	163.5	109.5	47.0
	MB	2.5	3.0	1.0	1.0	0.8	1.3	14.0	17.5	87.5	32.5	0.5	0.5
	LB	0.0	0.0	0.0	0.0	0.0	0.1	2.0	34.0	21.0	3.5	0.0	15.5

Table 34. Mean annual catch per unit of effort for standard bottom trawl drags from the upper, middle, and lower sections (UB, MB, and LB respectively) of the Bay of Quinte. No fishing was done in 1982. All data are from Hurley (1986)

Species	Location	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1983
Alewife	UB	284.1	286.7	482.2	362.7	614.9	184.9	22.0	949.8	249.6	1158.9	265.0
	MB	379.6	615.7	563.8	229.4	922.6	46.9	83.7	479.3	97.8	340.5	100.4
	LB	353.8	222.1	1374.6	443.6	1493.6	182.9	168.9	31.3	39.1	1471.4	1469.4
Gizzard Shad	UB	6.4	3.9	1.8	169.5	2.5	298.7	14.3	117.9	71.3	60.3	64.0
	MB	0.0	6.5	0.4	85.8	0.7	9.3	8.2	8.0	7.4	39.2	4.8
	LB	0.5	0.4	0.9	3.6	0.0	0.2	0.0	0.0	0.1	0.0	0.8
Rainbow smelt	UB	7.3	1.4	4.6	1.5	5.7	11.9	0.2	5.3	3.1	1.2	0.0
	MB	394.3	69.2	847.3	206.3	100.4	355.6	189.3	9.0	27.1	237.9	13.4
	LB	486.4	137.5	169.4	830.0	411.4	593.2	668.3	373.0	281.7	1335.5	2399.6
Spottail shiner	UB	4.8	1.6	0.6	1.7	0.7	0.2	1.2	0.4	5.7	0.3	4.0
	MB	15.9	5.5	4.2	2.7	4.0	4.0	41.0	7.5	0.1	0.8	19.6
	LB	0.4	0.3	0.1	7.3	57.7	1.5	7.3	1.2	0.2	5.9	33.0
Brown Bullhead	UP	9.3	16.3	10.1	36.7	18.4	7.3	1.6	6.6	2.0	12.2	1.4
	MB	4.6	14.0	6.0	43.4	23.6	10.5	2.0	0.6	0.3	9.7	0.8
	LB	0.0	0.0	0.0	0.3	0.0	0.1	0.0	0.0	0.0	0.0	0.0
American eel	UB	6.3	6.8	3.1	4.1	4.3	4.6	0.9	4.1	0.5	4.3	1.2
	MB	6.0	2.6	4.3	7.3	4.6	2.0	0.9	0.6	0.6	3.7	1.0
	LB	0.2	0.2	0.0	0.3	0.1	0.1	0.1	0.0	0.0	0.0	0.2
Trout-perch	UB	23.3	14.9	7.9	12.4	45.1	1.2	1.3	1.5	0.8	5.6	9.4
	MB	5.3	7.1	2.0	2.0	4.7	1.3	2.5	1.8	0.6	16.4	70.4
	LB	21.0	18.7	19.7	131.2	195.7	11.3	51.7	5.5	4.6	37.0	226.0
White perch	UB	286.4	297.0	169.9	1061.8	270.0	539.4	1.5	92.3	66.3	721.8	103.6
	MB	478.6	452.9	240.9	461.8	718.7	335.0	4.0	30.3	35.1	194.6	14.2
	LB	386.5	781.0	92.9	155.3	314.3	25.7	0.8	0.3	2.3	29.0	8.6
Yellow perch	UB	59.5	17.7	6.1	20.8	35.6	34.8	1557.1	130.5	20.3	90.7	23.6
	MB	22.8	19.7	17.4	18.4	7.0	16.6	32.5	12.2	2.5	170.1	141.0
	LB	13.4	11.8	13.3	20.3	11.9	0.6	0.9	1.2	0.8	109.1	60.4
Walleye	UP	0.3	0.0	0.1	0.2	0.1	0.6	27.7	8.5	0.5	7.0	7.4
	MB	0.2	0.0	0.0	0.0	0.1	0.0	8.7	6.7	2.4	5.5	17.0
	LB	0.0	0.0	0.0	0.0	0.1	0.0	0.1	0.8	0.1	0.2	6.2

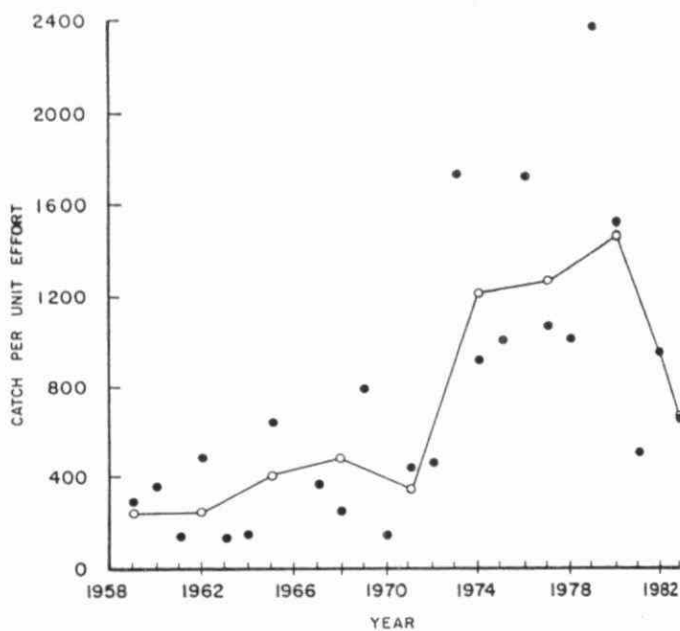


Figure 33. Catch per unit gill net effort for alewife at Hay Bay; o, annual means; o, means for three year periods (from Hurley 1986).

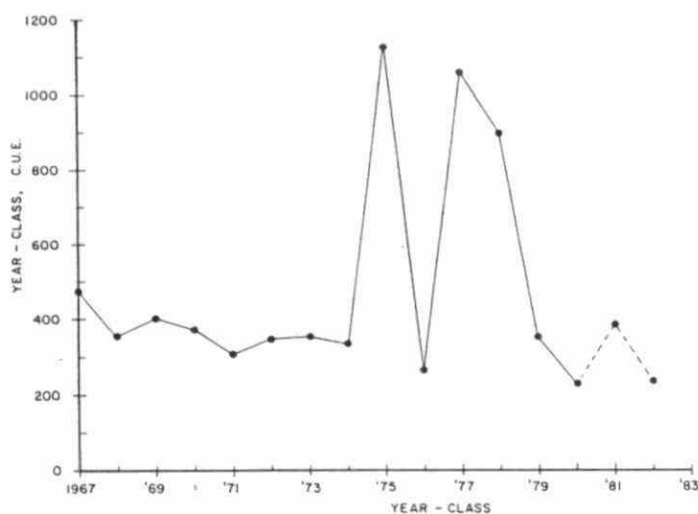


Figure 34. Calculated year-class CUE for white perch year-classes from 1967 to 1982 based on gill net catches. Broken lines indicate estimates based on less than 50% age class representation (from Hurley 1986).

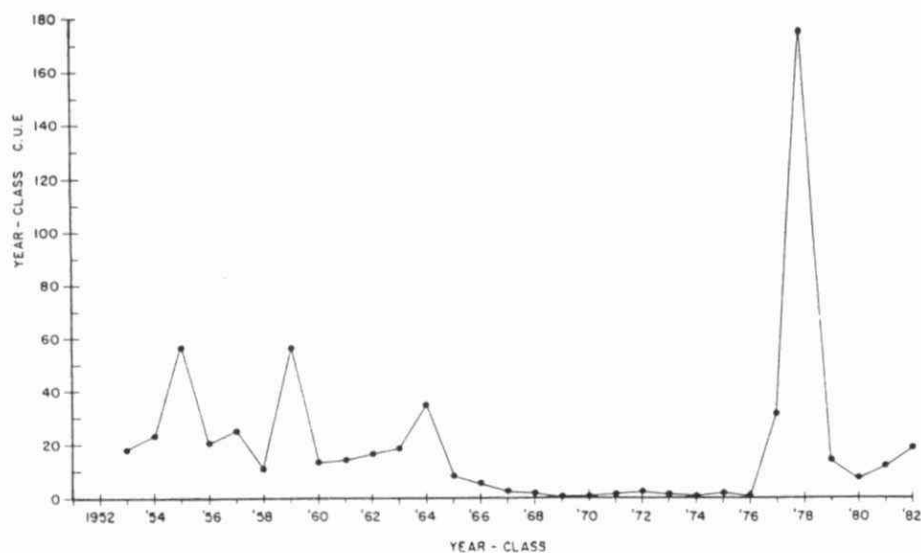


Figure 35. Calculated year-class CUE for walleye year classes from 1953 to 1982 based on gill net catches. The value for 1982 is based on less than 50% age-class representation (from Hurley 1986).

Osmeridae: In earlier years, rainbow smelt were abundant only in the middle and lower bays. Adults were taken in May and June in the lower bay, and in recent years, their numbers have decreased (Table 33). However, recent trawls have taken large numbers of young-of-the-year (YOY), especially in the lower bay (Table 34).

Esocidae: Northern pike is the only esocid abundantly present in the Bay of Quinte. Since 1972, numbers have gradually increased in the upper bay; however, year to year variability has been large. Similarly, northern pike are present in the middle bay, although there is no recent evidence to suggest an increase in abundance. The lower bay produces few northern pike, and numbers have declined since 1978.

Both grass pickerel and muskellunge occur within the bay; however, their numbers are not significant.

Cyprinidae: Most cyprinids were taken in the nearshore, although carp, golden shiner and spottail shiner also were taken in the open waters of the bay. Carp has formed much of the biomass, especially in the upper bay and middle bay; a few individuals were caught in the lower bay. According to Hurley (1986b), "Spottail shiners were taken in trawl drags in all areas and in all years (Table 34), and were also common in seine drags (Table 35). Although their numbers were variable over the years, there was a definite increase in all areas in 1983 (Table 33). Other cyprinids were less abundant in seine hauls, but since the nearshore community was not sampled as extensively as the offshore community, levels of abundance of some species may not be truly represented."

Catostomidae: Seven sucker species are present in the Bay of Quinte, but only the white sucker exists in appreciable densities. Catches indicated that the population of white suckers has been increasing since the late 1970s (Table 33). As well, long term data from Hay Bay show that this species has recovered from the low population densities of the the mid-1960s and early 1970s; although stocks have not returned to the levels seen in the late 1950s and early 1960s.

Table 35. Catch per unit effort for cyprinids from nearshore beach seines in the Bay of Quinte (from Hurley 1986b).

Species	1980	1981	1982
Spotted shiner	19.1	10.1	7.2
Spotfin shiner	0.3	3.4	0.0
Bluntnose minnow	0.3	8.5	1.8
Fathead minnow	0.9	0.2	0.0
Blackchin shiner	0.0	0.2	0.0
Golden shiner	0.0	0.6	0.0
Carp	0.0	0.1	0.0
Emerald shiner	0.0	0.1	0.0
Sand shiner	0.0	0.0	0.2
Longnose dace	0.0	0.0	0.2

Ictaluridae: As reported by Hurley (1986b), "Among the three ictalurids found in the bay, brown bullhead and channel catfish were largely restricted to the upper and middle areas of the bay (Table 33). Stonecats were infrequently captured in gill nets set in deeper water at Indian Point and Lennox in the lower bay ... Gillnet catches of brown bullhead increased during the 1972 to 1977 period but fell below the 1972 level, after 1978. Trawl catches appear to follow the same trend but the maximum catches occurred in 1975 (Table 34). The average size of these fish taken in the trawls was smaller than from gill nets. Trapnet catches of brown bullhead were highest in the 1969-71 and 1981 periods and lowest in 1978 and 1979. Channel catfish were taken in relatively large numbers by trap nets in the upper bay."

Anguillidae: American eels were taken in almost every trawl in the upper bay and middle bay. Few individuals were caught in the lower bay (Table 34).

Pericopsidae: Trout perch were caught mainly in bottom trawls, infrequently in gill nets and never in trap nets or nearshore seine hauls. Highest numbers were in the lower bay with populations peaking in 1976 and again in 1983.

Perchthyidae: White perch was the second most common fish species, after alewife, found in the Bay of Quinte (Tables 33 and 34). White perch invaded the bay in the 1950s via the Hudson River and Erie Canal. Numbers increased gradually through the 1960s. A consistent decline began in 1972, and in 1978, a virtual collapse occurred. However, stocks seem to have recovered recently, as indicated by numbers taken in gill nets; this rejuvenation is not as apparent through numbers of fish caught in trawl drags.

Centrarchidae: The greatest number of smallmouth bass occur in the upper bay, with smallest numbers in the lower bay (Table 33). Since 1978, numbers of this species have increased substantially in the upper bay. This trend was not paralleled in the middle bay where habitat may be poorer. Other centrarchids taken at most locations include rock bass, pumpkinseed sunfish, black crappie, largemouth bass, and bluegill.

Percidae: Numbers of yellow perch were generally lower in the upper bay and highest in the lower bay (Table 33). These differences were particularly apparent after 1979. When the number of yellow perch increased in the lower bay following the collapse of the white perch stocks. Trawl catches were generally low throughout the bay (Table 34), except in 1978 when large numbers of YOY yellow perch were taken in the upper bay.

Catches of walleye were low throughout the Bay of Quinte in the early and mid-1970s. In 1978, the number of walleye in the bay increased dramatically (Tables 33 and 34). Figure 35 is a long-term calculated year-class catch per unit effort (CUE) trend for walleye, based on gillnet catches. Large year-classes occurred in 1955 and 1959, numbers declined gradually through to 1976, and the 1977 and 1978 year classes have been the largest since the 1950s. Hurley (1986b) concluded that "...year-class strength for 1979 and later years appears to be approaching the level shown by the majority of year classes in the 1957-1964 period". This trend is confirmed by the numbers of YOY walleye taken in bottom trawl drags since 1978 (Table 36).

3.8.2 Fish Community Structure

Prior to 1950, the Bay of Quinte supported a community dominated by lake herring, lake whitefish, walleye, yellow perch and northern pike (Hurley 1986b). As well, various species of centrarchids, ictalurids, and osmerids were well-represented locally. This fish community was a mesotrophic one and both species diversity and persistence were high.

Phosphorus loading increased between the mid-1940s and 1970s, and the upper bay passed quickly through mesotrophy to eutrophy to hypereutrophy. Many changes to the fish community paralleled this enrichment process. First, by the mid-1940s, lake herring largely disappeared, probably as a result of predation on their young by osmerids (Christie 1973). Second, lake whitefish survived to the 1960s but succumbed to the effects of predation by white perch and degraded spawning habitat (Hurley and Christie 1977). Third,

Table 36. Mean number of age 0 walleye per hectare from bottom trawl drags in the Bay of Quinte, May-October

Year	Location		
	Big Bay	Hay Bay	Conway
1987	5.7	13.9	15.5
1986	49.5	21.2	22.8
1985	17.8	18.8	0.0
1984	1.6	5.0	0.0
1983	2.5	2.5	4.4
1982	32.7	0.0	0.0
1981	5.5	1.5	0.8
1980	0.0	0.0	0.0
1979	0.0	3.4	0.0
1978	29.4	12.2	0.0
1977	0.0	0.0	0.0
1976	0.0	0.0	0.0
1975	0.0	0.0	0.0
1974	0.0	0.0	0.0
1973	0.0	0.0	0.0
1972	0.0	0.0	0.0

3.8.3 Fish Contaminants

On the basis of information provided in the Guide to Eating Ontario Sport Fish (1988), contaminant levels have been determined and assessed for 14 species of fish at seven locations throughout the Bay of Quinte (Appendix J). While acceptable levels occur in most species and sizes, PCB and/or Mirex in excess of provincial and federal guidelines for consumption are persisting in large size classes of some species. Walleye greater than 65 cm in length and channel catfish greater than 55 cm in length should not be consumed at all. As noted by Beak Consultants Limited (1988), trends to declining levels have been observed in most fish species. Specifically, concentrations of mercury and DDT are now below consumption guidelines. While a similar decline has occurred for PCB, annual mean levels in American eel and channel catfish are still above the provincial fish consumption guideline. The various reductions are consistent with trends reported for Great Lakes fish over the past decade (Ministry of the Environment 1988).

Because of the importance of walleye to the Bay of Quinte, the Ministry of the Environment recently undertook an evaluation of available mercury, PCB and Mirex data (Table 37), with the following results:

- In 1975, only low PCB and Mirex levels were detected; mercury averaged 0.34 mg/kg and reached 1.49 mg/kg in a single 73.5 cm, 4,380 gm fish.
- The 1981 collections provided varying results, and consequent consumption advisories. Of the 52 walleye tested, only one, a 77 cm, 4,360 gm female, exceeded all three fish consumption guidelines.
- The contaminant-length curves for 1981 and 1985 Hay Bay walleye (Figure 36) would result in little significant difference in consumption advice, without the presence of the single 77 cm, 4,360 gm walleye referred to

Table 37. Mercury, PCB and Mirex in the Bay of Quinte walleye (data provided by A. Johnson, Ministry of the Environment).
Consumption guidelines are 0.5 mg/kg for mercury, 2 mg/kg for PCB and 0.1 mg/kg for Mirex.

Location	Year No		Length (cm)			Weight (gm)			Hg (mg/kg)			PCB (mg/kg)			MIREX (mg/kg)		
			Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
Bay of Quinte	1968	22	33	26	55.4	480	100	2300									
Belleville	1975	15	47	35	73.5	1550	550	4380	0.34	0	1.49	0.250	0.080	0.500	0.010	ND	0.030
Hay Bay	1981	8	51	36.0	77.0	1515	430	4360	1	0	2.10	0.932	0.086	3.132	0.062	ND	0.322
Trenton	1981	24	46	34.3	72.1	1120	574	4225	0	0	1.20	0.452	0.094	1.405	0.019	ND	0.146
Belleville	1981	16	40	33.0	51.0	644	320	1510	0	0	0.25	0.106	0.027	0.435	0.002	ND	0.017
Telegraph Narrows	1981	4	56	48.1	63.8	2002	1132	2889	0	0	0.39	0.425	0.011	0.777	0.018	ND	0.035
Hay Bay	1985	20	41	27.3	66.7	886	200	3355	0	0	0.58	0.182	0.032	0.665	0.011	ND	0.082
Nearshore	1985	17	55	45.5	66.1	1844	960	3254	0	0	0.86	0.826	0.090	2.660	0.051	ND	0.165
North Channel																	
Trent River	1987	19	54	26.3	73.0	2293	161	4217	1	0	1.10	0.084	ND	0.214	0.010	ND	0.032
Keith Shoal	1987	20	55	31.9	74.6	2119	298	5094	0	0	0.90	0.149	ND	0.485	0.023	ND	0.067
Gravelly Bay	1987	18	62	46.0	73.3	4859	994	5236	1	0	0.96	0.340	0.041	1.340	0.038	0.007	0.196

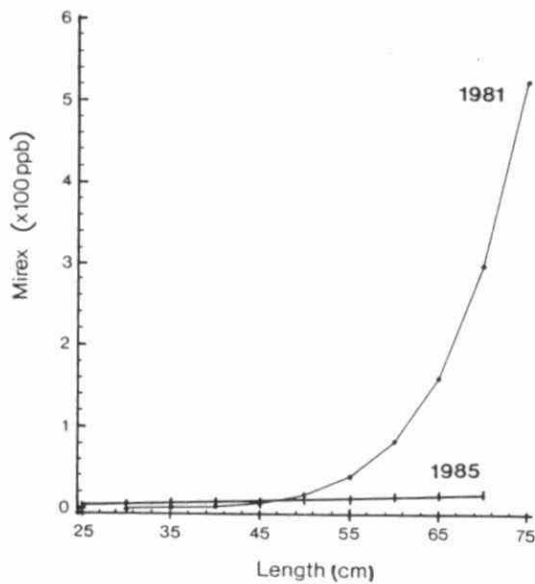
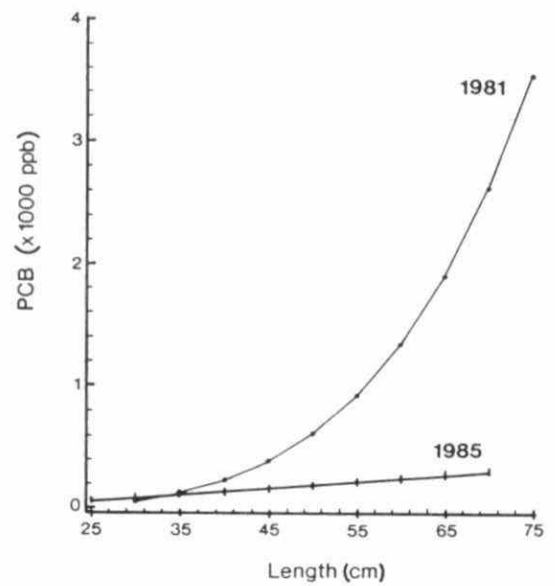
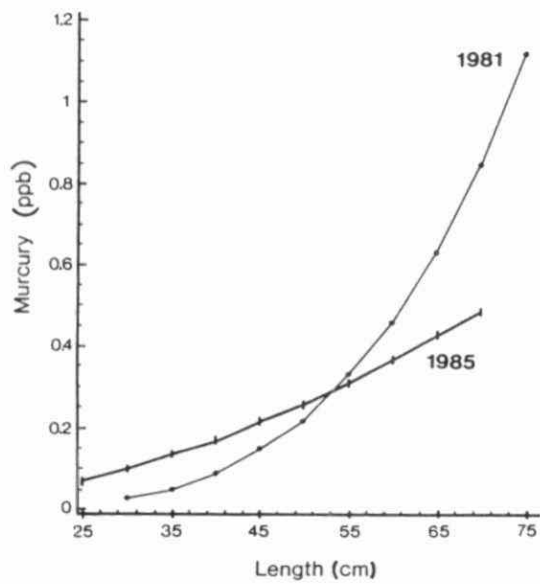


Figure 36. Length versus contaminant levels in Bay of Quinte (i.e., Hay Bay) walleye, 1981 and 1985 (unpublished Ministry of the Environment data).

above. Also, clearly shown is the reduction in contaminant levels between years.

- The 1987 walleye were collected from the mouth of the Trent River, Keith Shoal in Adolphus Reach, and from Gravelly Bay outside the bay proper. The fish were much more comparable in size than previous collections, although the Gravelly Bay fish lacked the small walleye found at the other two locations. Figure 37a indicates closely comparable length weight curves. The best fit mercury versus total length curves (Figure 37b) suggests that the Keith Shoal walleye would have a slightly less restrictive consumption advisory than walleye collected at the other two locations. PCB concentrations in all specimens were less than the 2,000 ug/L fish consumption advisory guideline (Figure 37c). While calculated PCB concentrations were quite similar for 45 cm fish from all these locations, there are considerable differences for example, between Keith Shoal and Trent River walleye, and Gravelly Bay and Trent River walleye. Levels of Mirex showed a similar pattern as PCB results (Figure 37d). The 1987 collections were also analyzed for arsenic; in this regard, the arsenic versus total length curve (Figure 37e) for Trent River walleye was considerably lower than the curves for the Keith Shoal and Gravelly Bay samples, suggesting a higher availability of arsenic at the latter locations.
- Comparison of 1985 data from the North Channel with 1987 information from the mouth of the Trent River, Keith Shoal and Gravelly Bay indicate that while the length, weight and total length-mercury curves are similar for all four data bases (Figures 38a and 38b). However, the PCB and Mirex values in larger North Channel walleye are considerably higher than at the other locations (Figures 38c and 38d).
- Recent data from the Fox River and Green Bay area of Lake Michigan indicate that while length-weight relations are similar (i.e., when compared with those of Trent River, Gravelly Bay and Keith Shoal walleye), PCB levels in Fox River walleye are considerably higher than

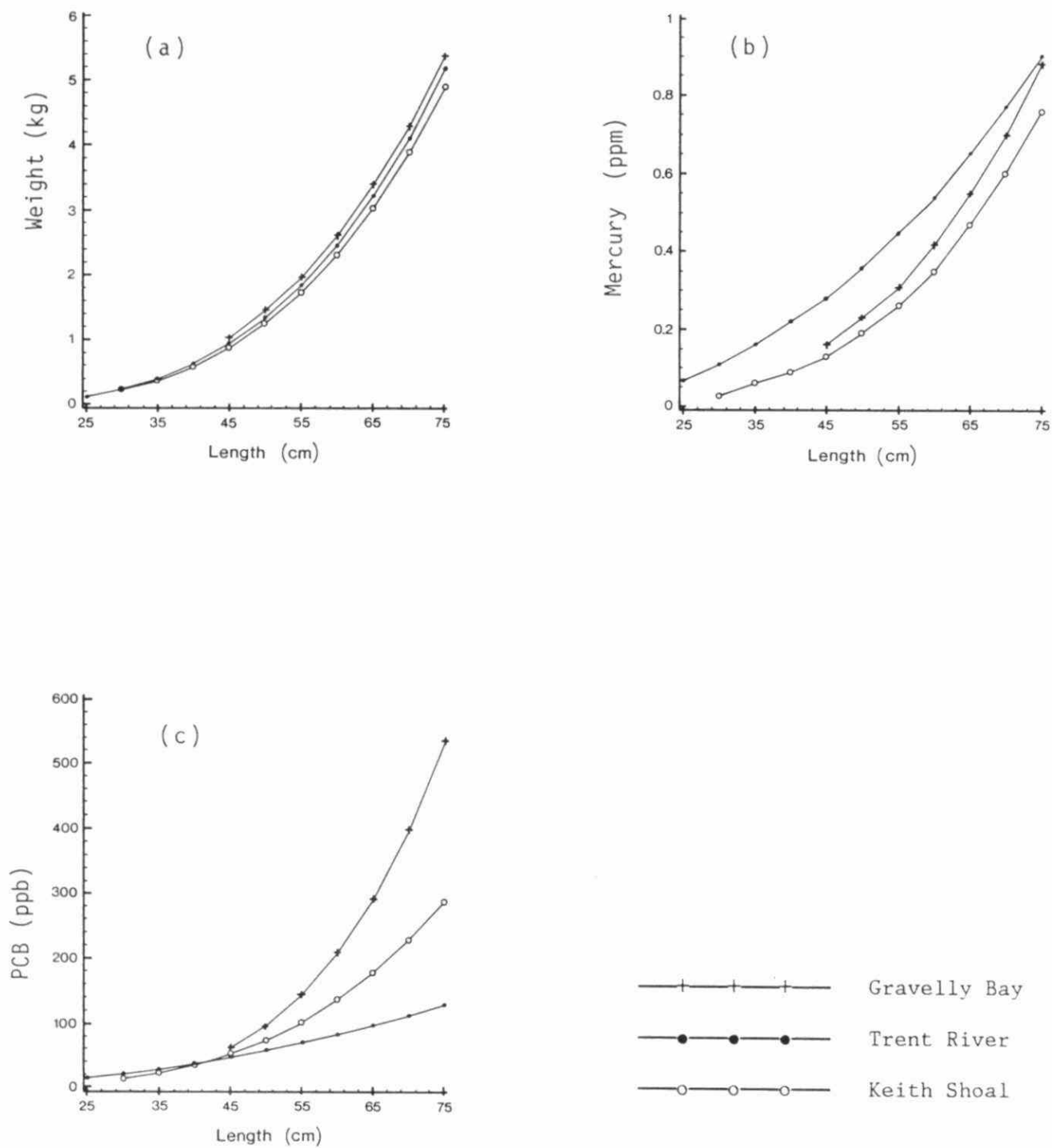


Figure 37. Length versus weight and length versus mercury, PCB, Mirex and arsenic relationships in walleye taken from Bay of Quinte waters, 1987 (unpublished Ministry of the Environment data).

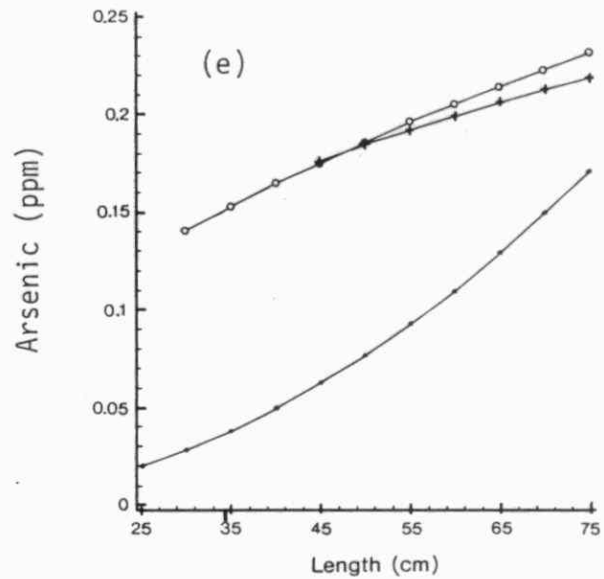
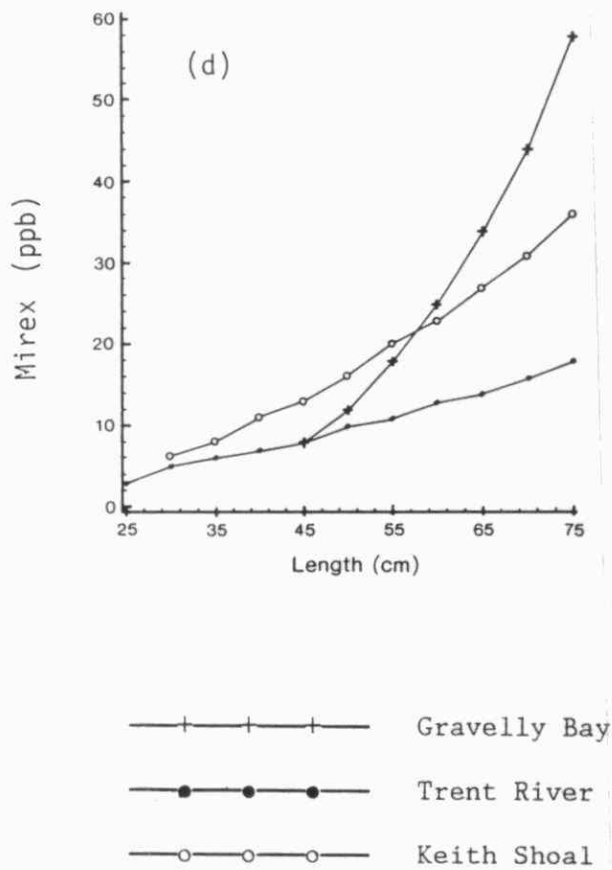
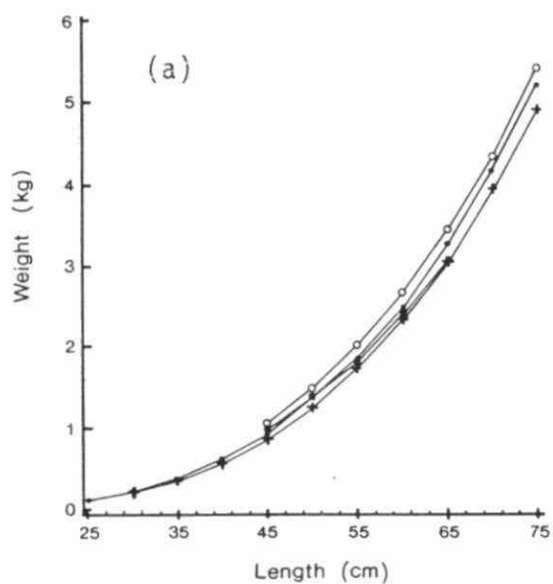
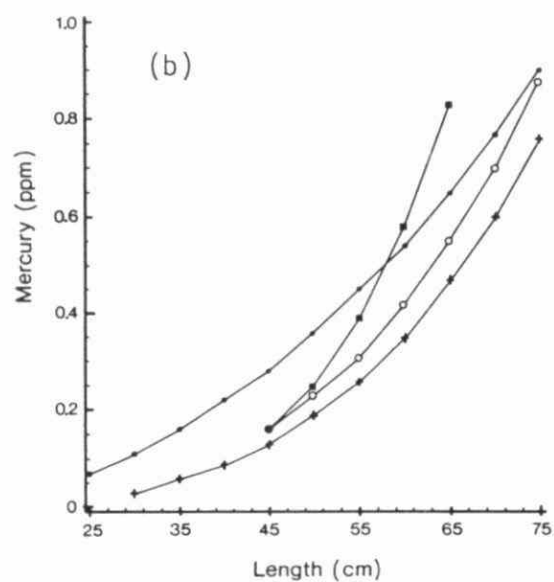


Figure 37 (continued).



—○— Keith Shoal
—●— Trent River



—○— Gravelly Bay
—■— North Channel '85

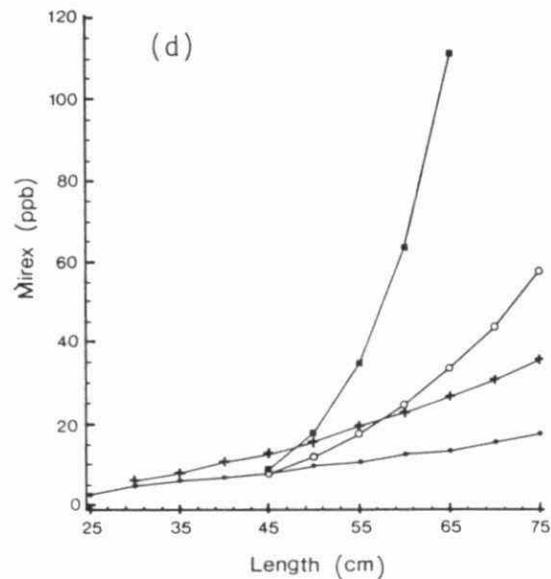
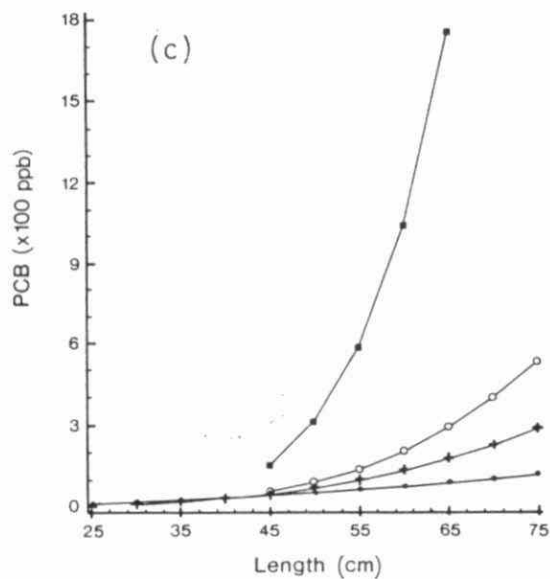


Figure 38. Length versus weight and length versus mercury, PCB, and Mirex relationships for walleye, Bay of Quinte area (1987) and North Channel of Lake Ontario (1985) (unpublished Ministry of the Environment data).

those reported for Bay of Quinte fish (Figures 39a and 39b). Apparently, the Fox River and Green Bay walleye feed heavily on contaminated Green Bay smelt. The data in Figure 39b suggest either that PCB concentration are low in the Bay of Quinte waters or that walleye are feeding on prey which are low in PCB content. In any event, there were no Ontario fish in this data base which exceeded the Ministry of the Environment's fish consumption guidelines of 2,000 ug/L.

- In summary, consumption guidelines for mercury, PCBs, Mirex and other contaminants are only occasionally exceeded in Bay of Quinte walleye, and only in larger fish. As well, a clear long-term trend to declining concentrations is evident to the Quinte fisheries.

In 1987 and 1988, large walleye (i.e., >55 cm) were analyzed for dioxins and furans in edible portions of flesh. Total concentrations of all dioxin forms detected, expressed as toxicity equivalents of 2,3,7,8 - TCDD ranged from 15 ng/g to 118 ng/g in 1987, and from 8 ng/g to 115 ng/g in 1988. Because some of the levels exceeded Health and Welfare Canada's consumption guidelines of 20 ng/g, further sampling and analyses were undertaken in 1989. In this regard, edible portions of five large walleye (i.e., >55 cm) taken from the Bay of Quinte and Prince Edward Bay (eastern Lake Ontario) were analyzed for dioxins and furans. The average level detected in fish expressed as total toxicity equivalents of 2,3,7,8 -TCDD was 5.1 ng/g, with concentrations ranging between 2.4 ng/g and 11.2 ng/g. Not only were these levels below the Health and Welfare Canada consumption guidelines, but they were similar to levels found in fish taken elsewhere in Lake Ontario.

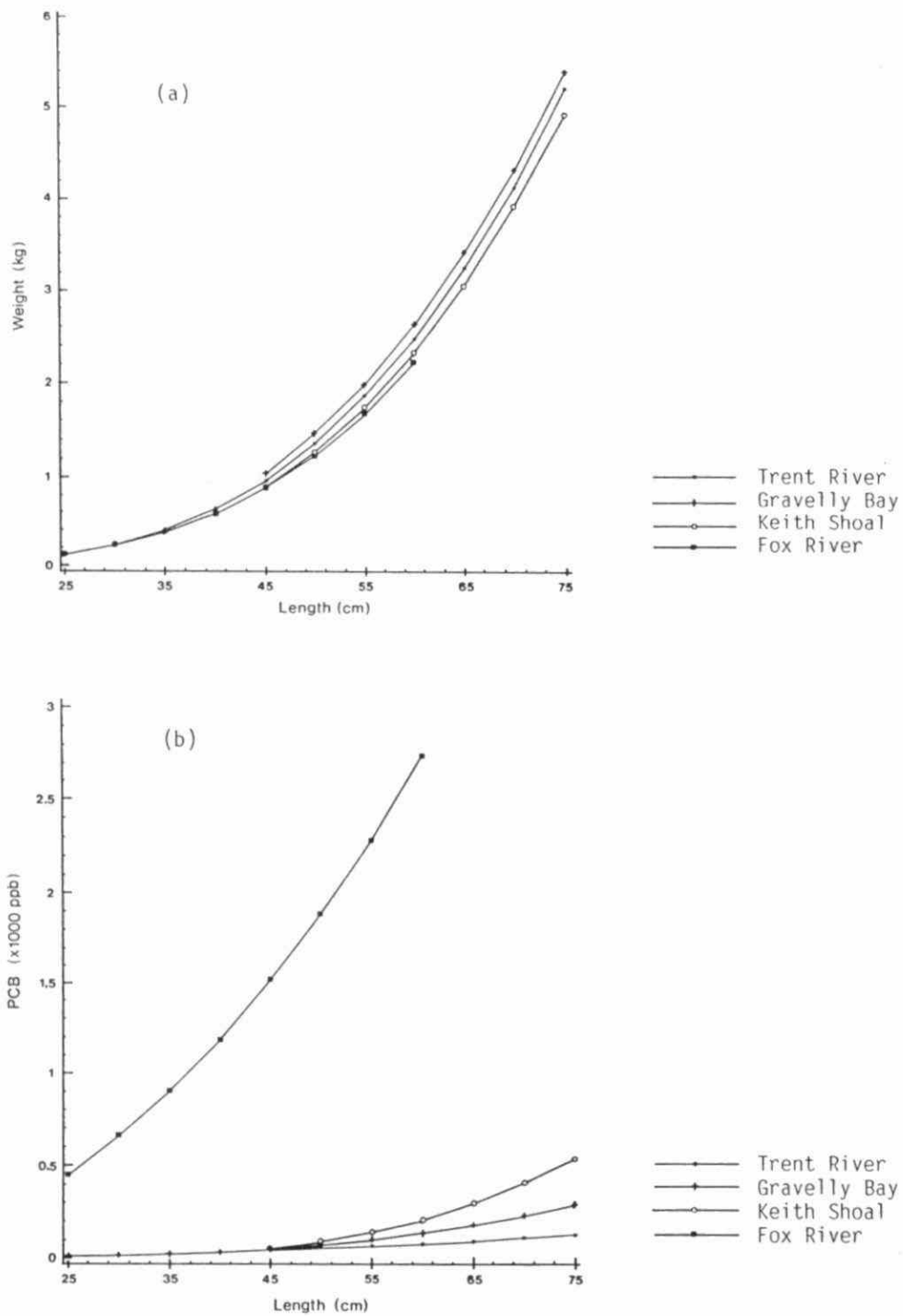


Figure 39. Length versus weight and length versus PCB relationships in walleye from the Bay of Quinte waters and the Fox River/Green Bay area of Lake Michigan (unpublished Ministry of the Environment data and Liebenstern for the Fox River/Green Bay information).

4.1 INTRODUCTION

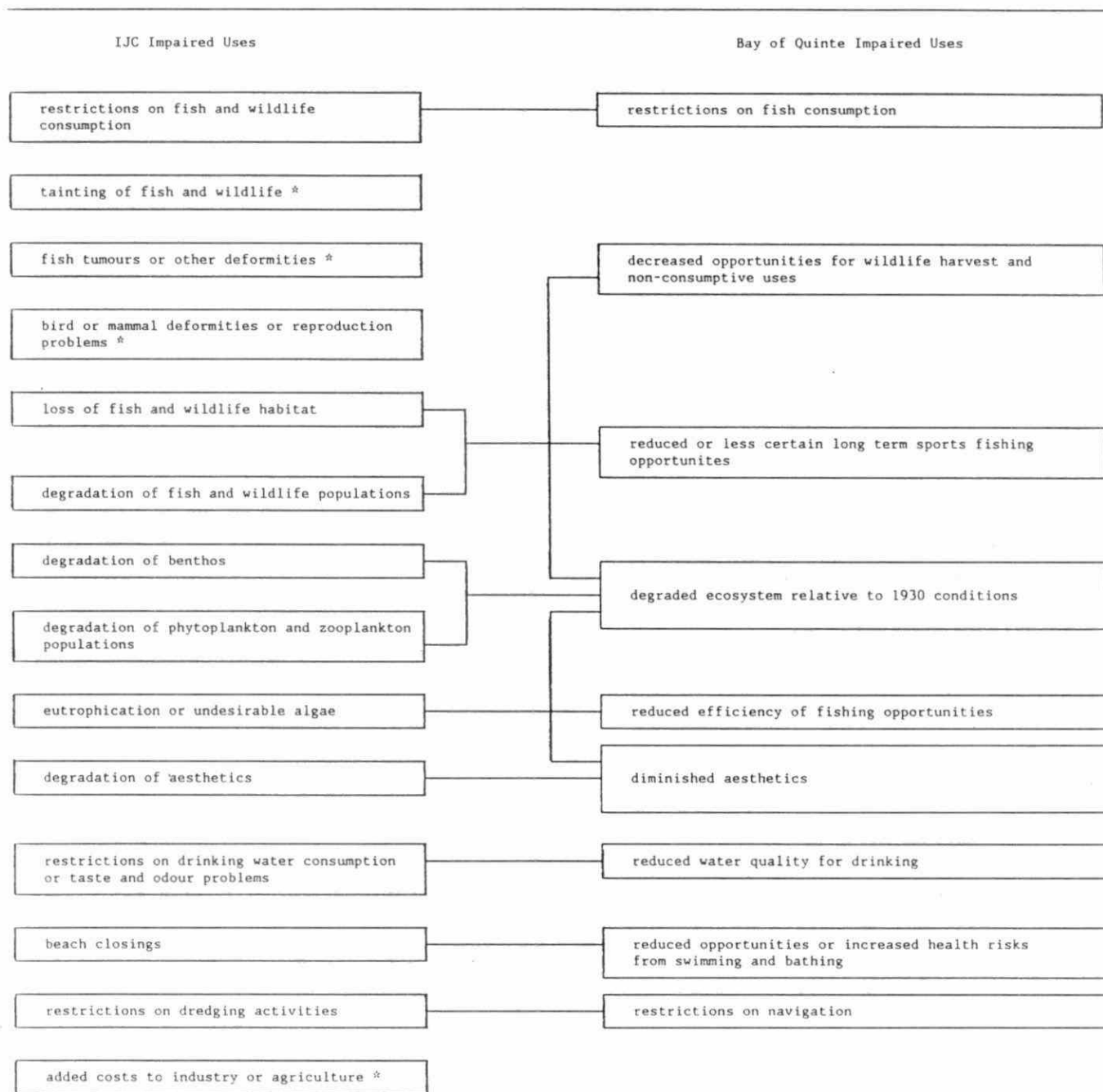
The Revised Great Lakes Water Quality Agreement of 1978, as amended by a protocol signed on November 18, 1987 identified fourteen impaired beneficial uses for the Great Lakes and their contiguous waters (Article 8, Annex 2). An impairment of a beneficial use is considered to be a change in the chemical, physical or biological integrity of a system sufficient to cause any of the effects shown in Figure 40.

A revised list of nine impaired uses specific to the Bay of Quinte was confirmed at two modelling workshops (Figure 40). Six were related to problems of elevated nutrient levels and three were associated with increased levels of toxics and bacterial contamination. Four IJC impaired uses were not considered to be a concern in the Bay of Quinte.

Ecosystem indicators for the nine impaired uses and a variety of potential remedial actions were identified at the two workshops. The hypothesized linkages between impaired uses, their ecosystem indicators and various remedial actions are shown in Figure 41. This figure defines the bounds of the RAP for the bay from an ecosystem perspective, and provides the conceptual framework for assessing the effects of alternative remedial actions to improve the quality of water, sediment and biota in the bay. Also shown are "non-pollutional" elements of the Bay of Quinte RAP; they relate to the physical alteration and destruction of the ecosystem and imbalances in composition and health of the bay's aquatic plant and animal communities.

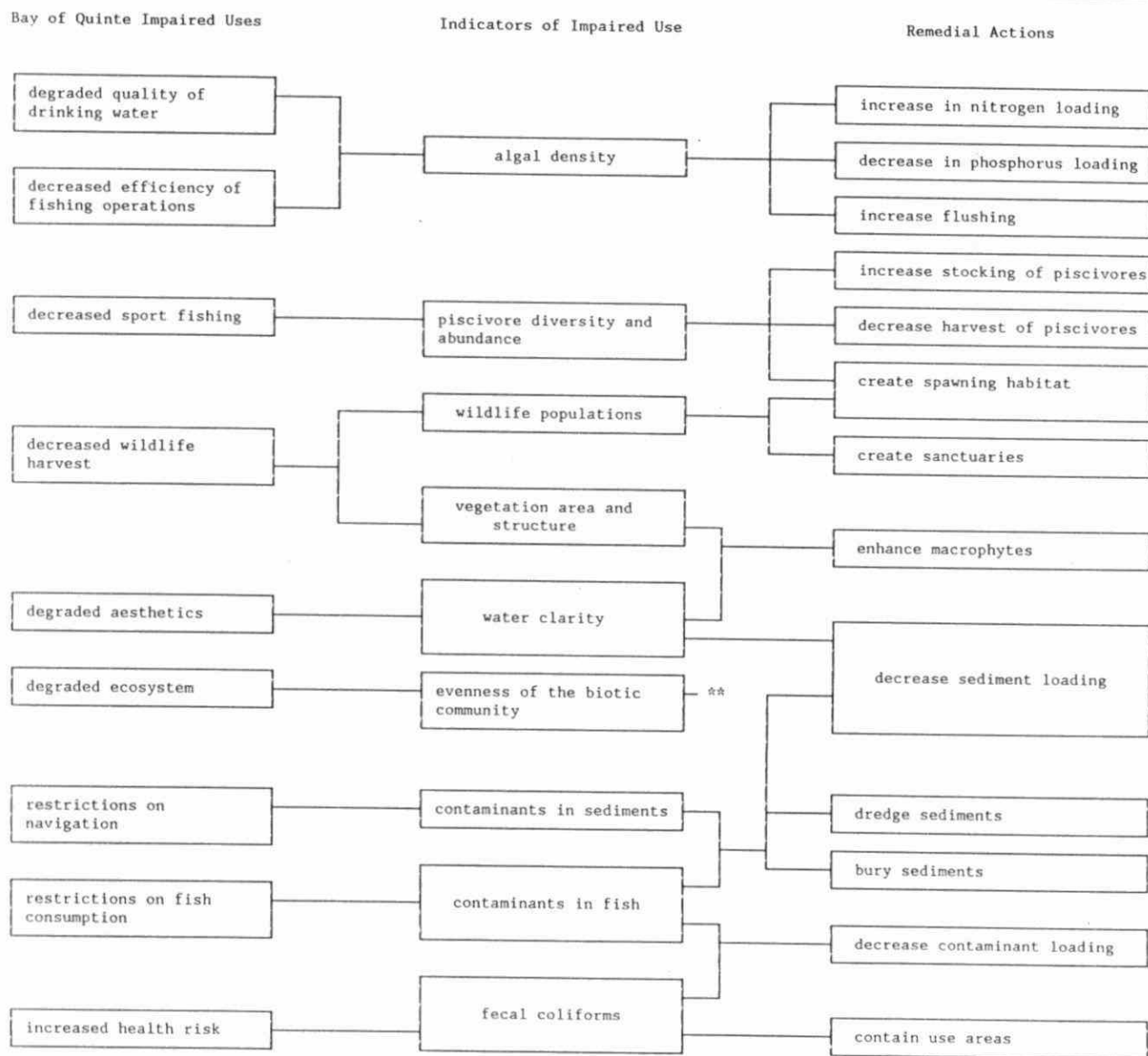
In this section of the report, technical information is presented to confirm key concerns and related uses which are specific to the Bay of Quinte.

Figure 40. Differences between IJC impaired uses and Bay of Quinte impaired uses determined at ecosystem modelling workshops, 1988 (from ESSA 1988).



* - IJC impaired uses not seen as a concern in the Bay of Quinte.

Figure 41. Relationships between impaired uses, their indicators and possible remedial actions in the Bay of Quinte (from ESSA 1988).



☆ - the first nine remedial actions all affect evenness of the biotic community

4.2 KEY CONCERNS

4.2.1 Eutrophication

1. Phosphorus inputs from local sewage treatment plants, though substantially reduced when compared to pre-1977 loadings, may still be too high. In the late 1960s, the area sewage treatment plants were discharging about 215 kg/day into the bay. The first reduction in loadings occurred between 1973 and 1976 as a result of federal regulations restricting the phosphorus content of laundry detergents; this brought the sewage treatment plant loadings down to about 160 kg/day. In 1978, the loadings were reduced further to about 75 kg/day, as local sewage treatment plants commenced treatment for phosphorus removal. In fact, actual loadings since 1977 have averaged 71 kg/day for the annual, and 64 kg/day for the May to October period. Further progress in removing phosphorus from the sewage treatment plant discharges was made in 1987, bringing current discharge loadings down to 32 kg/day. The annual guideline of 1.0 mg/L phosphorus in the effluent has been met at all plants with the exception of Napanee and Prince Edward Heights. The May to October guidelines of 0.5 mg/L has been approached but not met consistently at all plants.
2. There are some recent changes occurring in the limnology of the Bay of Quinte which are inconsistent with the initial benefits which resulted from reduced phosphorus loadings. In Figures 26 and 27, the immediate benefits of phosphorus controls are indicated. Total phosphorus concentrations and algal densities showed excellent improvements in the five years after 1977. However, in 1984 and 1985, a return to higher phytoplankton densities was observed. The May to October average algal levels were comparable to values measured during the pre-phosphorus control period. These increases in algal biomass occurred even though phosphorus concentrations in the water remained relatively stable (i.e., about 50 ug/L). Further, the increases have occurred despite continued success with the phosphorus removal control program. Even in 1986 and 1987 when ice-free mean phosphorus concentrations in the upper bay were

the lowest on record (i.e., 31 ug/L and 37 ug/L), phytoplankton stocks did not decrease. The relevant question then becomes, "What factors are acting to maintain high algal densities, even though phosphorus concentrations are clearly declining?"

3. There is currently insufficient technical information on how much phosphorus is stored in the sediments of the upper bay, what its annual release is to overlying waters, and how long the release will continue. Internal sediment feedback affects water quality in the bay. During the pre-phosphorus control period, the system's sediments were acting as a phosphorus sponge or sink, capturing and storing phosphorus. However, over the past decade, the sediments have been pumping phosphorus back into the water column in sufficient quantities to further enhance algal production. This situation will eventually stop; however, the time frame is unknown.
4. Further water quality improvements in the Bay of Quinte may depend on managing individual components of the food chain. However, the expertise and methodologies are unavailable. While much is still not known about how the food web functions in the bay, it is likely that changes in fish populations have, by indirect effects on the aquatic food chain, influenced the phytoplankton biomass.

Nicholls and Hurley (1989) showed the lack of any significant relationship between phytoplankton and phosphorus concentration in the upper bay when the data were separated for the pre- and post-phosphorus control time periods. More specifically, when the data were analyzed on the basis of these periods, correlation coefficients of 0.679 and 0.265 were determined for phytoplankton - total phosphorus relationships at Station B for the 1972-1977 and 1980-1987 periods respectively (Figures 42 and 43). A similar relationship was found for the phosphorus-phytoplankton-fish data from Hay Bay for the 1972-1978 period (Figure 44). These analyses suggest that the recent fluctuations in phytoplankton have been influenced by factors other than phosphorus.

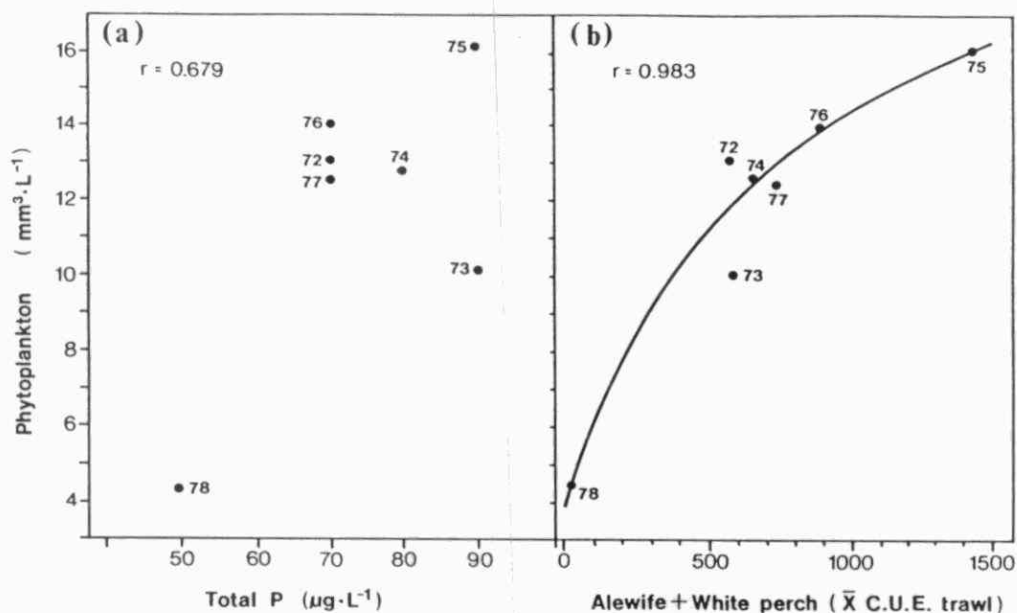


Figure 42. Relationships between May to October average phytoplankton biomass (mm^3/L) and total phosphorus concentration ($\mu\text{g}/\text{L}$) at Station B in the upper Bay of Quinte, 1972-1978 (a), and average phytoplankton biomass at Station B and mean catch per unit effort of alewife and white perch from standard bottom trawl drags in the upper Bay of Quinte (b) (from Nicholls and Hurley 1988).

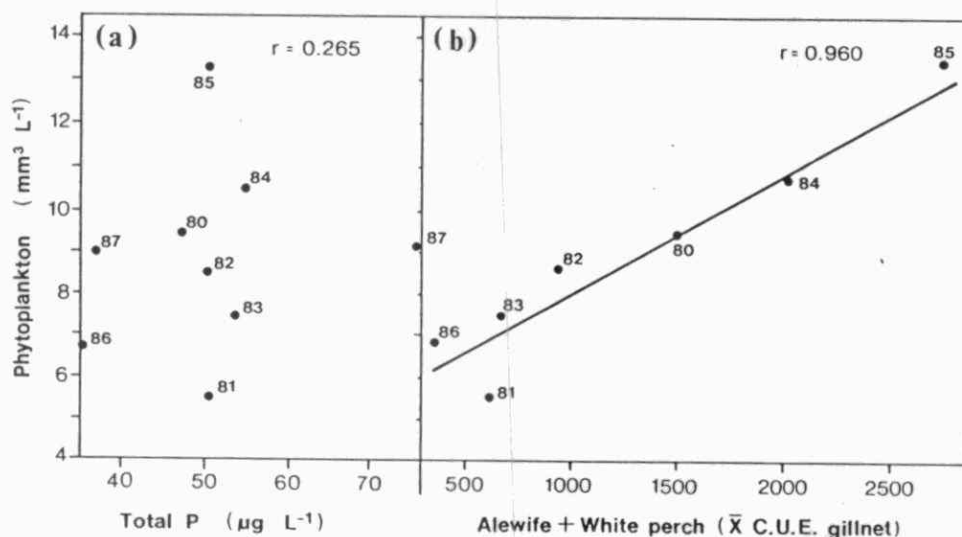


Figure 43. Relationships between May to October average phytoplankton biomass (mm^3/L) and total phosphorus concentration ($\mu\text{g}/\text{L}$) at Station B in the upper Bay of Quinte, 1980-1987 (a), and average phytoplankton biomass at Station B and mean catch per unit effort of alewife and white perch from standard gill net lifts from the Bay of Quinte (b). Trawling was done only once in 1982 and gill nets were not set in the upper bay in 1985, so data from the middle Bay of Quinte gill net sets were used; the position of the line, and the correlation coefficient shown do not include the 1987 data in (b) (from Nicholls and Hurley 1988).

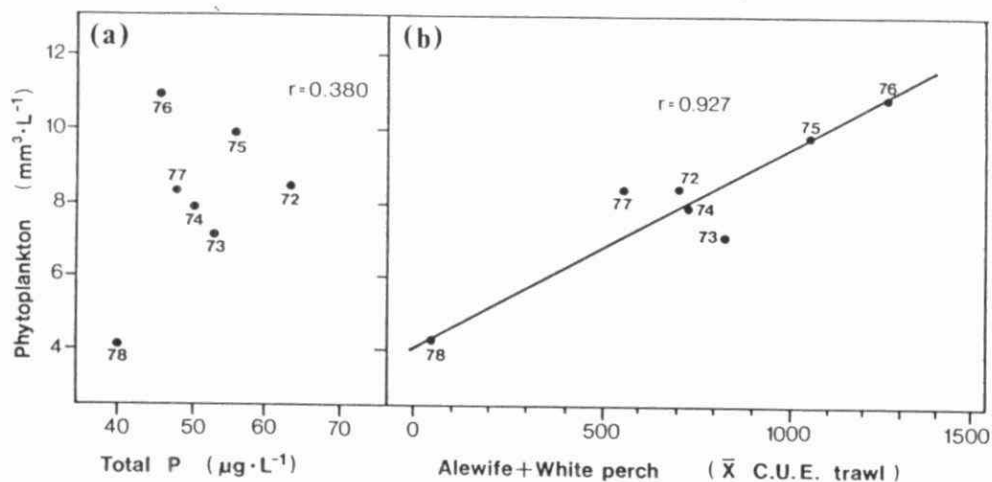


Figure 44. Relationships between May to October average phytoplankton biomass (mm^3/L) and total phosphorus concentrations ($\mu\text{g}/\text{L}$) at Station HB in the middle Bay of Quinte, 1972-1978 (a), and average phytoplankton biomass at Station HB and mean catch per unit effort of alewife and white perch for standard bottom trawl drags in the upper and middle Bay of Quinte (b) (from Nicholls and Hurley 1988).

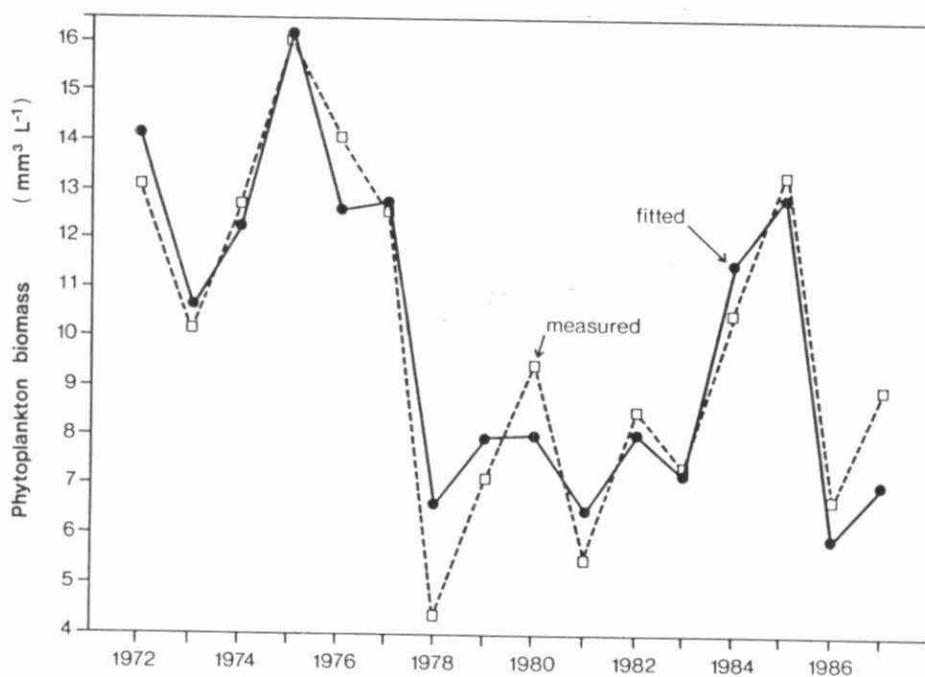


Figure 45. Relationships between measured and fitted average May to October phytoplankton biomass in the upper Bay of Quinte, 1972-1987, based on a multiple regression model including five input variables of which white perch biomass explained more than 50% of the variance in the model (from Nicholls and Hurley 1988).

While phosphorus loadings may determine the upper limit of phytoplankton production and biomass accrual, planktivore and benthivore (especially white perch) biomasses, or factors correlated with these biomasses, may also be critical. For example, in the shallow upper Bay of Quinte, most of the abundant fish species are zooplanktivores in their early life history. However, a major portion of the upper bay's total fish biomass is adult white perch which are predominantly benthivores.

If the major trophic influence of fish on phytoplankton in the upper bay is through planktivory, then there should be a negative correlation between phytoplankton and zooplankton. However, strong correlations were not apparent (Nicholls and Hurley 1989), mainly because the upper bay is dominated by small bodied zooplankton such as C. sphaericus which are unable to utilize large algae like Melosira spp. and various blue green species.

If Daphnia become more abundant through changes in fish predation, some reductions in Melosira and blue-green algal biomass might occur. However, because these algae comprise the bulk of the summer phytoplankton biomass, net changes would likely be small, despite much greater utilization by Daphnia of the less well-represented, but more "food-chain functional" species of algae (Nicholls et al. 1986). Nicholls and Hurley (1989) hypothesized that consumption of the diatom Melosira by benthic oligochaetes and chironomids during quiescent periods of sedimentation may be the most important biotic influence on summer phytoplankton in the shallow upper Bay of Quinte. It is believed that grazing of Melosira by Chironomus during quiescent periods of algal sedimentation results in a significantly smaller "innoculum" for subsequent planktonic growth during turbulent re-suspension events. In support of this, Nicholls and Hurley (1989) presented a multiple regression analysis in which white perch biomass explained most of the variance between phytoplankton biomass and several other parameters (Figure 45). Accordingly, the size of the Melosira population will therefore be controlled to some degree by the rate of loss through

herbivory by benthic organisms during quiet periods, and this, in turn, may be controlled by the extent of benthic feeding by white perch.

Other internal factors, such as the low density of rooted aquatic plants, also have an indirect but significant effect on the balance and health of the bay's ecosystem. These plants provide shelter for zooplankton. Lack of habitat leaves the zooplankton vulnerable to predation by white perch and alewife. As a result, little zooplankton predation on phytoplankton occurs. Rooted plants in the bay also dissipate the energy of wind and wave action, and therefore minimize the physical disturbance of sediments which, in turn, reduces the physical re-suspension of phosphorus from sediments.

Thus, further reductions in algal densities may not be achieved by additional loading controls alone, but must depend on a combination of nutrient loading reductions (both external and internal) and management of fish habitat and community structure. As well, the re-establishment of a balanced and stable fish community dominated by desirable predator species (i.e., the larger piscivorous percids, centrarchids and esocids) may depend on the restoration of lost macrophyte beds.

5. Surface accumulations of blue-green algae (i.e., water blooms) continue to undermine the aesthetic appeal of the Bay of Quinte. As well, the species which contribute to these blooms are potential toxin producers. In other parts of the Kawartha-Trent system, they have been the cause of animal deaths. Sub-clinical effects on humans include flu-like symptoms and skin and eye irritations; however, no specifics are known about possible health effects on humans and other animals using the Bay of Quinte. Optimal use of parks, beaches, picnic sites, and open shoreline areas, to a great degree, depends on a high quality environment; the presence of frequent and lasting water blooms clearly undermines the realization of this objective.
6. High water temperatures and objectionable tastes and odors continue to

plague the drinking water of municipalities along the Bay of Quinte. These two problems are not mutually exclusive in that warm water is much less desirable than cold water for most consumers, and the presence of odorous compounds produced by algae is less readily detectable by consumers if the drinking water is cold. In the Bay of Quinte, the algae which produce offensive flavors develop highest numbers during periods of warmest water temperatures. Of course, these are also the months when demand for treated water is the highest.

4.2.2 Bacteriological Contamination

1. Bacterial contamination has curtailed swimming and other recreational uses of the Bay of Quinte and its watershed. The following areas have been most seriously affected.
 - The lower reaches of the Trent River at Trenton and the nearshore waters of the Bay of Quinte at Bain Park beach.
 - Riverside Beach on the Moira River south of Highway 401; this beach was posted in August, 1983 and again in July, 1986. The beach is affected by two storm sewer discharges just upstream, as well as runoff entering the Moira River at the Corby Distilleries Ltd. outfall, about 3 km upstream of Riverside Beach.
 - Much of the lower Moira River within the City of Belleville, although not designated as a swimming area, has fecal coliform counts in the order of 100 to 300/100 mL after rainfall. As well, several storm sewers and ditches have significant flows and high bacterial counts, even in dry weather, suggesting the existence of illegal cross-connections, sanitary discharges, or other unknown sources.
 - The north side of the Napanee River and downstream, following rainfalls.
 - Picton Bay to within a few hundred metres of Picton Marsh Creek.

4.2.3 Heavy Metal and Toxic Organic Contamination of Surface Waters

Historically, heavy metals (i.e., iron, copper, zinc, cadmium, lead and nickel), phenols and various toxic organic contaminants in excess of the MOE's water quality objective for the protection of aquatic life have been found in Bay of Quinte surface waters (see Section 3.1.9.1 - Heavy Metals and Organic Contaminants: Historical Perspective). More recently (i.e., 1988), concentrations of copper (in 7% of the samples), cadmium (6%) and iron (2%) in Bay of Quinte waters have exceeded the same Provincial Water Quality Objectives.

As well, metals (i.e., iron, copper, zinc, nickel and lead) have historically been found in STP and industrial streams discharging to the bay. In 1988, relatively high concentrations of aluminum were found in STP effluents at Deseronto (i.e., 550 ug/L), Napanee (i.e., 310 ug/L) and Picton (i.e., 680 ug/L). As well, copper (i.e., 32 ug/L), manganese (i.e., 110 ug/L) and zinc (i.e., 31 ug/L) concentrations were elevated in the Trenton STP effluent. At Domtar Wood Preserving, high iron concentrations (i.e., 1,400 ug/L) were present in its industrial effluent, and at Trent Valley Paperboard, high concentrations of aluminum (i.e., 2,600 ug/L), copper (i.e., 120 ug/L), manganese (i.e., 380 ug/L) and zinc (i.e., 85 ug/L) were measured in its effluent stream. Domtar Packaging was a source of almost every metal sampled in 1988. Concentrations in the effluent discharge were: 5,450 ug/L for aluminum, 50 ug/L for chromium, 109 ug/L for copper, 1,300 ug/L for iron, 510 ug/L for mercury, 550 ug/L for manganese and 230 ug/L for zinc.

The most frequently detected organic compound, both historically and in recent surveys, has been PCP. In 1988, concentrations in the Domtar Wood Preserving "North Outfall" discharge ranged from 27 ug/L to 2,200 ug/L, while at Trent Valley Paperboard, concentrations in effluent discharges ranged from 0.61 ug/L to 3.5 ug/L. PCP was also found in effluent samples at every Bay of Quinte STP (i.e., 65% of all samples taken) ranging in concentrations from

a minimum of 0.030 ug/L at Deseronto to 0.9 ug/L at Trenton.

Other organics have been found, but in most cases, only in trace concentrations.

Metals and organic parameters have not exceeded provincial guidelines for drinking water relating to public health in treated waters at the Belleville, Deseronto and Bayside School water treatment plants.

4.2.4 Sediment Contamination

1. Sediments in the Trenton, Belleville, Deseronto and Picton areas contain heavy metals such as arsenic, cadmium, chromium, copper, iron, mercury, nickel, lead, zinc, and PCBs which exceed provincial guidelines for open water disposal of dredged sediment.
2. Heavy metals and toxic organics such as PCB and PCP may be incorporated into the food chain by bottom-feeding organisms, or via physical resuspension and/or chemical reaction. Consequently, these substances may contaminate desirable fish, resulting in restrictions on human consumption.

4.2.5. Fish and Wildlife Habitat

1. Nearshore and deepwater habitats of the Bay of Quinte have been physically altered, fragmented and/or lost. To date, remedial measures and abatement actions have focused on the obvious causes of degradation. A need exists to direct attention on protecting and maintaining the existing supply of fish and wildlife habitat and, even more importantly, on re-establishing some of the rooted plant communities that existed 50-60 years ago. Such actions would offset lost opportunities for fish and wildlife harvest and increase non-consumptive recreational uses.

4.2.6 Commercial and Sport Fisheries

1. Information needs to be acquired on how many fish can be safely harvested without depleting overall stocks. During the 1980's the harvest of commercial and sport fish exceeded 400,000 kg/year, about 301,000 kg/year from the commercial fishery and 132,5000 kg/year from the sports fishery. Using conventional assessment techniques, the Bay of Quinte has an annual maximum sustainable yield of about 161,000 kg, meaning that the bay is currently being overharvested. However, fisheries managers believe that conventional methods of estimating fish productivity (i.e., based on estimates of sustainable yield) may not be appropriate to the Bay of Quinte.
2. There is insufficient information on what the desirable fish species mix should be, and the combination of measures required to control or stabilize the structure of the fish community. There are considerable dangers in harvesting only one or two top level predators, and fisheries managers must provide mechanisms which would maintain a broad base of top level piscivores (i.e., walleye, northern pike, large and smallmouth bass, etc.). Currently, individual allocations are provided by species for each commercial fishing licence, and for sport fisheries, daily creels in combination with restricted season lengths are the measures used.
3. Ways and means of controlling the existing sport harvest, particularly walleye, will need to be determined, evaluated in terms of angler acceptability, and implemented. In 1986, 200,780 kg of sport fish were taken, half of which were walleye. It is clear that ways to control this harvest are needed if high quality angling opportunities are to be maintained in light of anticipated increase in demand.
4. Anglers and commercial fishermen need to be aware of basic principles regarding the dynamics of fish communities. For example, significant problems can occur by overfishing one species, then turning attention to

harvesting a second, less valued species.

5. The economic value of the sports and commercial fishery of the Bay of Quinte has not been fully determined. Studies have estimated the value of the walleye fishery between \$1.3 and \$5.8 million annually. Gross landed values are used to estimate the value of the commercial fishery, but economic spin off values must be added to properly judge the true worth of the fishery. Such information would be invaluable to resource managers, anglers, and the general public, especially when advancing convincing arguments for tighter pollution controls or securing approvals and/or funding to implement specific management tactics and remedial works (i.e., habitat).

4.2.7 Fish and Wildlife Contaminants

1. Some of the large sized, economically important fish such as walleye and channel catfish are restricted for human consumption, owing to levels of PCB and Mirex which occasionally exceed guidelines.
2. As well, there is a lack of information on sources, both general and specific. For example, little is known about how much of the PCB and Mirex contamination is generated from in bay sources and how much relates to transportation from Lake Ontario via migrating fish.
3. High levels of chlorinated hydrocarbons may be affecting reproductive success in double-crested cormorants and herring gulls. In this regard, birth defects in some birds and animals in the Great Lakes basin have been shown to be more prevalent than in control populations less exposed to toxic contaminants. The most publicized example is in chicks of double-crested cormorants; some are born with crossed bills and are unable to feed themselves after leaving the nests. More specifically, in four island colonies in Green Bay, Michigan, defects in young birds were 42 times greater than in colonies outside the Great Lakes basin (Kubiak 1988). Other defects observed in double-crested cormorants and other

birds include club feet, shortened appendages, missing eyes, no brains, major organs outside the body, and abnormal accumulation of tissue fluid. In the Bay of Quinte, no deformities have been found, nor have any reproduction problems been reported. However, high levels of chlorinated hydrocarbons may have or may be affecting eastern Lake Ontario populations of double-crested cormorants (Carroll 1988) and herring gulls (Muir and Sudar 1987). Of importance is that these problems are not isolated to the Bay of Quinte. Nonetheless, this potentially impaired beneficial use needs to be evaluated in the AOC.

5.1 INTRODUCTION

As indicated in Section 4, water quality in the Bay of Quinte is adversely impacted by excessively high levels of algae; unacceptable amounts of one or more heavy metals and/or toxic organics in water, sediments and/or fish; and periodic bacterial contamination. As well, non-pollutional concerns prevail: the physical alteration and destruction of portions of the bay's ecosystem, and imbalances in composition and health of aquatic plant and animal communities. In this section, factors causing the environmental concerns or impaired beneficial uses are presented.

5.1.1. Eutrophication

To date, measures to reduce phosphorus loadings to the Bay of Quinte have related to the construction and/or modification of local sewage treatment plants, and the Federal government's initiative in the early 1970s to legislate phosphorus reductions in detergents. However, the total supply of phosphorus to the bay comes from a variety of sources; these are presented in Table 38 together with estimated loading for 1987. The estimates are for the plant growth season (May 1 through to October 30). Loadings for the November to March period are not as important as summertime inputs because the upper bay's entire water volume is exchanged several times each spring, transporting with it the phosphorus loads that occur over the fall and winter months.

Tributaries: The inflowing tributaries are estimated to be contributing 382 kg/day of phosphorus. Agricultural land runoff contributes an estimated 320 kg/day, point source loadings from a number of upstream municipal sewage treatment plants (Peterborough, Hastings, Marmora, Campbellford, Frankford and Batawa) add about 50 kg/day, and the remaining load is natural (Ecologistics 1988). Agricultural activities and the inland sewage treatment plants can be controlled. For example, agricultural phosphorus loads could

Table 38. Estimated 1987 phosphorus loadings (kg/day) to the upper Bay of Quinte. All estimates are for the plant growth season which is April 30-October 30.

Source	Estimated 1987 Loading	Source
Tributaries	382	Minns et al. 1986
Sediment feedback	84-140	Beak 1989
Atmosphere	8	Minns et al. 1986
Sewage treatment plants	32	Owen 1988
Water treatment plant wastewater	5	Canviro 1987
Industries	15	Canviro 1987
Urban runoff	15	ESSA 1988

be reduced by converting tillage practices to either chisel plow or no-till operations. The reasonable estimated load reduction would be 25% or about 80 kg/day (Ecologistics 1988).

Sewage treatment plants: All of the Quinte area STPs currently provide secondary treatment and achieve phosphorus reduction to 0.5 mg/L during the May 1 to October 30 period. The measured phosphorus load in 1987 was 32 kg/day (Table 39). Table 39 also illustrates the substantial reductions that have been achieved at the six municipal treatment plants discharging directly to the bay. The improvements reflect reduced phosphorus in detergents in the early 1970s as well as phosphorus controls at the various plants since 1977. An estimated additional 12 kg/day loading reduction - about 38% of the present loads - could be achieved if the STPs could maintain 0.3 mg/L total phosphorus in their effluents during the May 1 to October 30 period (Canviro 1988).

Atmosphere: The 8 kg/day estimate represents the amount of phosphorus falling directly onto the surface waters of the Bay of Quinte. It was derived from measured data collected on a monthly basis between 1969 and 1981 at the Trenton and Kingston weather stations.

Sediment feedback: Field and laboratory studies (Beak 1989b) have confirmed that loadings of phosphorus from sediments are considerable (Table 38). Algal populations have remained high in the bay, even though reductions in point sources have been substantial, because internal loadings have been maintaining, in part, the high plant biomass in overlying waters. ESSA (1988) predicted that if no further action is taken to control point source phosphorus inputs concentrations in the bay should decline owing to reductions in internal loadings of phosphorus (Figure 46). A new sediment-water equilibrium should develop to reflect the most recent phosphorus control measures. Any new sediment should contain lower concentrations of phosphorus. The older, phosphorus-rich sediment would be buried, and the rate of internal loading decreased.

Table 39. Total phosphorus loads to the Bay of Quinte (kg/day) from sewage treatment plants for 1987 (Owen 1988). All inputs are derived from measured data. (T = Trenton, CFBT = Canadian Forces Base Trenton, B = Belleville, D = Deseronto, N = Napanee and P = Picton).

Period	T	CFBT	B	D	N	P	Total
1965-1972	53.0	13.0	110.0	2.7	20.0	15.0	214.0
1973-1976	47.0	5.9	73.0	2.3	17.0	11.0	156.0
1976-1977	43.0	2.1	39.0	2.3	63.0	9.1	158.0
1978-1986							
Jan-Dec	7.5	1.9	31.0	0.9	24.0	2.4	68.0
May-Oct	6.3	1.7	25.0	0.7	24.0	1.9	60.0
1987							
Jan-Dec	5.9	2.7	16.0	0.6	11.0	2.1	38.0
May-Oct	6.4	2.0	15.0	0.5	6.2	1.8	32.0

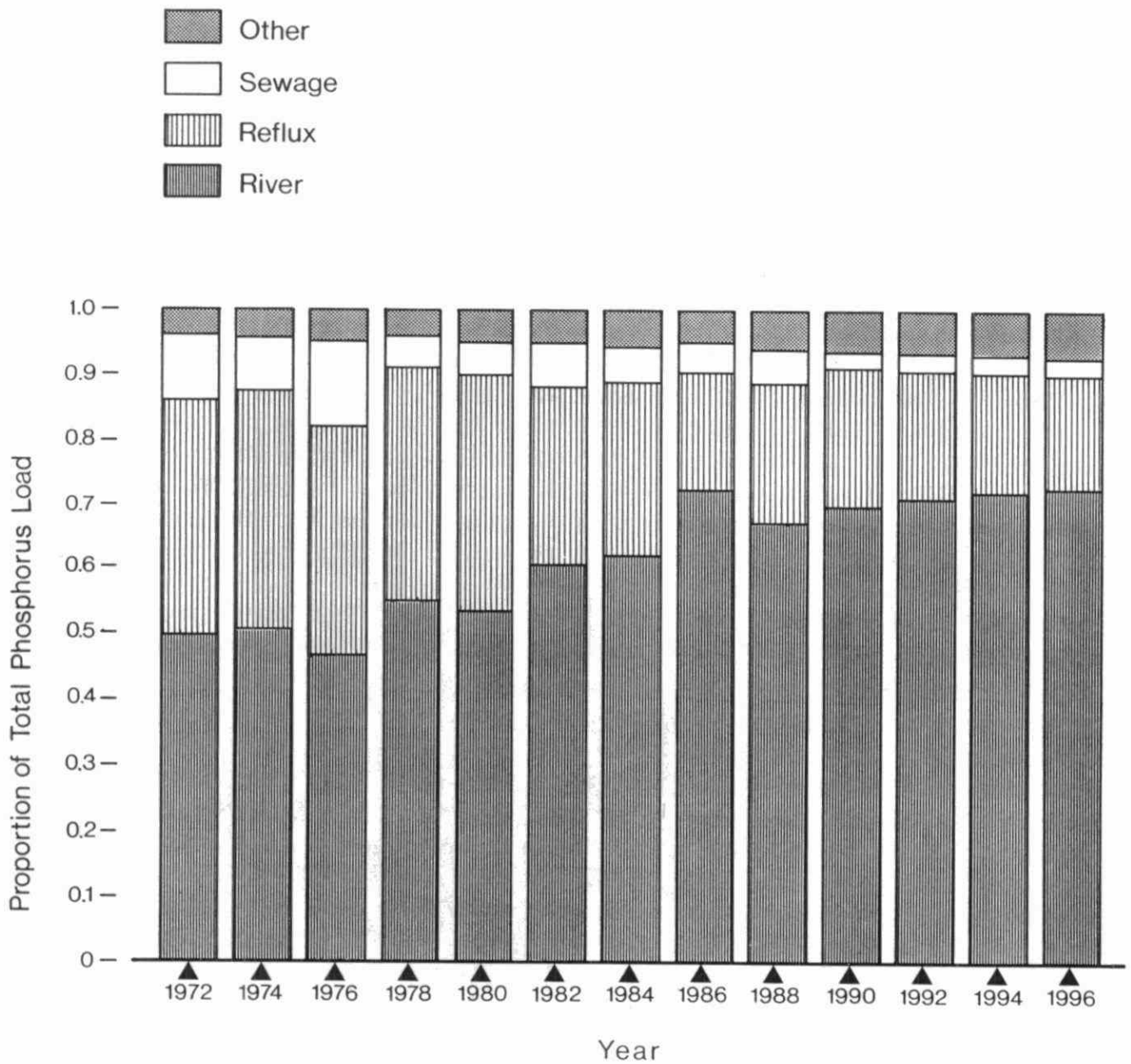


Figure 46. Relative contribution of different sources of phosphorus to the summer phosphorus load (May to October) in the upper Bay of Quinte. "Other sources include storm sewers, industrial effluent and treated sludge from water treatment plants (from ESSA 1988).

Water treatment plant wastewater: At present, there is no net loading of phosphorus to the Bay of Quinte from the five water treatment plants drawing water for municipal purposes; the treatment plants are simply returning what is taken from the bay. However, if the treatment plants discontinue the practice of discharging filter backwash and sludge to the bay, there would be a net reduction in phosphorus loadings to the bay, amounting to about 5 kg/day (Canviro 1988).

Industries: At present, the industrial wastewater dischargers do not provide phosphorus removal. The 1987 estimated total phosphorus loadings from Trent Valley Paperboard Mills, Domtar Packaging, Corby Distilleries and Strathcona Paper was about 15 kg/day (Canviro 1988). Treatment for phosphorus removal is feasible.

Urban runoff: Urban areas contribute phosphorus to the Bay of Quinte via their storm sewer systems. ESSA (1988) assumed these inputs to be proportional to the size of urbanized areas in the watershed, equal to about 50 km². Using a phosphorus load of 1.6 kg/ha/year, and assuming that 60% of the total storm sewers loads enter the bay directly (i.e., as opposed to via tributaries), a phosphorus input equal to 15 kg/day was estimated.

Food chain intervention: As noted earlier, the Bay of Quinte ecosystem has not responded as expected to phosphorus control efforts. Instead, algal densities continue to fluctuate widely, and a balanced fish and wildlife community has not yet materialized. In Section 4, a strong statistical correlation was shown between algal biomass and the biomass of white perch and alewife, suggesting that Daphnia was not developing in sufficient numbers to graze down the bay's algal stocks. Even if Daphnia becomes abundant through reduced fish predation, numbers would not likely be sufficient to produce noticeable changes in summer phytoplankton. This is because the ice-free algal stocks are dominated by the diatom Melosira and a variety of blue-green species, all of which are poor quality food items. Nicholls and Hurley (1989) hypothesized that white perch could be having a strong influence on summer phytoplankton in the upper bay by grazing on bottom

dwelling macroinvertebrates, which would otherwise be exerting a control on algal stocks, particularly Melosira. Nicholls and Hurley (1989) presented a multiple regression analysis in which white perch biomass explained most of the variance between phytoplankton biomass and several other parameters (Figure 45). Accordingly, the Bay of Quinte's fish stocks are keeping the system's planktivores (i.e., zooplankton and bottom fauna) cropped to the extent that little feeding on algae is occurring. In turn, these events might be related to the scarcity of rooted aquatic plants, which provide shelter for plankton and habitat for northern pike and largemouth and smallmouth bass.

In summary, resource managers are generally of the view that rehabilitation of the Bay of Quinte ecosystem, will depend on further decreases in point source phosphorus loadings, protecting the existing supply of fish and wildlife habitat, and perhaps more importantly, re-establishing some rooted plant communities.

5.1.2 Heavy Metals and Toxic Organic Contaminants

Heavy metals: As indicated in Section 3.1.9.2, there has been a long term trend towards reduced levels of heavy metals in the waters and tributaries of the Bay of Quinte, although in 1988, copper, cadmium and iron levels still exceeded Ontario Ministry of the Environment's Provincial Water Quality Objectives for the protection of aquatic life at a number of locations.

Most concentrations of heavy metals in tributaries and /or sediments reflect the impacts of past industrial activities in the watershed, such as pulp milling, mining and smelting. However, the 1988 sampling program indicated that present industrial effluent discharges also are a source of heavy metal pollution. Specifically, effluent discharges at Domtar Packaging contained a variety of heavy metals in high concentrations, while Domtar Wood Preserving's effluent is a source of elevated iron, and Trent Valley Paperboard Mills is a source of aluminum, copper, manganese and zinc.

As well, high levels of various heavy metals historically have been found in the Trenton, Belleville, Deseronto, Napanee and Picton STP effluents, which may be the result of industrial discharges to municipal sewers. As noted, in 1988, high concentrations of copper, iron and cadmium were found in Trenton's STP discharge, while aluminum levels were high at the Deseronto, Napanee and Picton STPs.

Inland landfill sites are a potential source of cadmium, copper, zinc, nickel and iron to the Bay of Quinte; however, the degree of contamination is unknown and will depend on variables such as subsurface residence time and rate of biodegradation. Landfills located on or in close proximity to the shoreline of the Bay of Quinte may be a more significant source of heavy metals in the short term because of a potential increased movement of leachate and the shorter subsurface residency time (Beak 1988a).

Toxic organic contaminants: Cook (1988) reported that: (1) PCP concentrations in the discharges from the Domtar Wood Preserving operations have exceeded the Ministry of the Environment's criteria of 55 ug/L, and (2) PCP and other associated chlorophenols, dibenzo-p-dioxins and dibenzo furans (i.e., impurities of commercial grade PCP) have been identified in the Domtar Wood Preserving discharges. Actions were ordered by the MOE to clean up off-site contamination and improve the quality of wastewater discharges. In this regard, a new wastewater treatment system - consisting of dissolved air flotation for removal of solvent extractables, and activated carbon filtration for removal of dissolved phenols and chlorinated phenols - was installed in 1989, although the extraction efficiency of the system has not yet been fully evaluated. In 1988, the Trent River sediments were cleaned of any visible creosote and oil. A stormwater management system, and improved flow recording devices and reporting procedures are required as part of the MOE's control order.

High levels of phenolic compounds, most notably PCP, have been measured in most Bay of Quinte tributaries. As well, PCPs have been found in the effluent at every STP discharging to the Bay of Quinte, with highest levels

at Trenton.

Phenol and/or PCP exceedences in the Trent River have been identified with the Domtar Wood Preserving operation and, as well, may be associated with the Trent Valley Paperboard, and Domtar Packaging operations. Also, Bakelite Thermosets has discharged phenolic compounds directly to the Bay of Quinte, and in 1989 was charged and fined for violations of the Ontario Water Resources Act. Lastly, on the Napanee River, the Strathcona Papers plant is a potential source of phenolic discharges.

Both inland and shoreline landfill sites are potential sources of organic chemicals, particularly phenols, with actual contaminant movement depending on subsurface residence time and biodegradation rates. The effects of leachate discharges from four industrial waste disposal sites are unknown, and further investigation is required on chemical characterization of leachate originating from each site.

PCB exceedences of provincial dredge spoil disposal guidelines have occurred in sediments at the mouth of the Trent and Moira rivers. Elevated PCB levels also have been found in several fish species sampled in the Bay of Quinte. It is unclear whether the PCB levels in those fish are the result of PCB contaminated waters and sediments within the bay, or are from PCB sources external to the Bay of Quinte, since many of the piscivorous and planktivorous fish (i.e., American eel, walleye, alewife) inhabiting the bay migrate between the bay and Lake Ontario. Accordingly, actions to reduce PCB levels in Bay of Quinte sediments and water may not reduce fish body burdens in the Area of Concern.

Three former coal gasification plant sites occur at Belleville, Deseronto and Napanee; these are potential sources of PAH. In a 1988 study of sewage and industrial effluents and tributaries, PAH was found only in the discharge stream of the Domtar Wood Preserving plant.

Under certain conditions (i.e., physical resuspension from wind-wave action or chemical transformations as a result of anoxia within the water column or at the sediment/water interface), heavy metals and toxic organics can be released from Bay of Quinte sediments into the overlying water. Thus, the bay's sediments are an important contaminant source and will remain so until substantial quantities of contaminants have been released from the sediments and flushed out of the system, or until sediment release is inhibited and the present contaminant loads are buried beneath a "cleaner" sediment layer.

5.1.3 Bacteriological Contamination

Bacteriological contamination is a problem in the Bay of Quinte and in rivers flowing into it. More specifically, bacterial contamination commonly occurs in the lower reaches of the Trent River and extending outward into the bay, in the Moira River and along the Belleville waterfront, at the mouth of the Napanee River, and at the head of Picton Bay near the Picton Marsh Creek point of discharge. As a result, bathing areas and beaches are often closed on the Trent River at Frankford, the Moira River in Belleville and the Napanee River at Newburgh. The following causative factors influence bacteriological conditions in Bay of Quinte surface waters.

5.1.3.1 Bypassing of sewage

Belleville: The sanitary and stormwater treatment systems are 90% to 95% separated (Canviro 1988). Extraneous surface water from the combined portion of the sewer system and inflow/infiltration result in high per capita flows. A recent upgrading of the sewer system and expansion of the STP has eliminated the bulk of the major bypassing. However, some bypassing still occurs at the Dundas West pumping station at Palmer Road, and the Dundas West and Coleman Street overflows. The 1984 STP enlargement enabled the facility to treat most of its wet weather flows; however, peak flows in excess of the plant's hydraulic capacity are diverted to a chlorine contact chamber for disinfection before discharge.

Trenton: Sanitary and stormwater sewers are totally separated. Some inflow/infiltration problems exist in a portion of Trenton's sanitary sewer system; no bypassing occurs from the collector system or at the sewage treatment plant.

CFB, Trenton: Sanitary and stormwater sewers are 80% to 90% separated. Extraenous waters from the combined sewers plus inflow/infiltration problems have resulted in flows which have exceeded the STP's hydraulic capacity. Excess flows in such cases are bypassed to a chlorine contact chamber for disinfection prior to discharge. In 1988, a very minor impact was found on one dry weather sampling period, and no impacts were found during wet weather.

Deseronto: The sanitary and stormwater sewers are totally separated and have sufficient capacity to avoid the need to bypass.

Napanee: The sanitary and stormwater sewers are 70% separated; the sanitary sewer system and STP have sufficient capacity to prevent bypassing.

Picton: The Town's sanitary and stormwater sewers are totally separated. Inflow and infiltration problems from illegal roof leader connections, cracked sewers and leaking joints result in high sanitary sewer flows. The STP's hydraulic capacity is frequently exceeded; yet there is no bypassing. Rather, the excess flows are diverted to a holding tank for sedimentation and chlorination treatment prior to discharge (Canviro 1988).

Prince Edward Heights: The sanitary and stormwater sewer systems are totally separated. However, the sanitary sewer system and STP are the oldest in the Quinte area. Large volumes of inflow water from roof drains and groundwater infiltration through leaking joints and cracked and broken sewers result in flows which exceed the sewer and STP hydraulic capacities. As a result, bypassing occurs both from within the sewer system, and at the STP. The STP discharges to the headwaters of Marsh Creek. Marsh Creek flows to Picton Bay at Picton. Studies of Picton bay have determined bacterial pollution attributable to the Marsh Creek inflow.

5.1.3.2 Sewer cross connections

Based on bacteriological studies at Trenton and Belleville during wet and dry weather conditions, there appears to be dry weather inputs of human wastes (Griffiths 1984, Poulton 1986, and Poulton 1989). This suggests the possibility of some household connections to the wrong sewer system (i.e., the storm sewer system).

5.1.3.3 Industries

Industrial wastewater discharges may contain bacteria of human origin. Industries have separate sewers and treatment systems for their human and process wastewaters. While this is the case at Domtar Packaging in Trenton, its process wastewater discharge still contains fecal coliform bacteria.

5.1.3.4 Stormwater runoff

As noted above, some illegal house connections and possible infiltration to storm sewers undoubtedly exist, and inputs occur during dry weather periods. Bacteria from the feces of domestic animals are normally present in urban stormwater. Many of the studies undertaken since 1981 have demonstrated the impacts of wet weather bacterial runoff. None of the Quinte area municipalities provide treatment of their stormwater.

5.1.3.5 Livestock

Runoff of livestock wastes from farmyards or manure spread on fields, and/or "problem" feces deposited at cattle watering sites are sources of bacteria. These sources are believed to be present throughout the agricultural portion of the Bay of Quinte watershed. The origin of the high bacteria levels found near Corby Distilleries is thought to be from agriculture.

5.1.3.6 Pleasure boats

The Province of Ontario has regulations which require boats with toilets to be equipped with holding tanks. It is illegal to discharge such wastes to the natural environment; however, a small percentage of pleasure boats discharge raw sewage overboard. Sink and shower wastes (i.e., grey water) can legally be discharged to surface waters, and some bacterial contamination is associated with these materials.

5.1.3.7 Landfill sites

Landfills located directly on the shoreline of the Bay of Quinte (i.e., at Trenton and Zwick's Island) may contribute bacteria to Bay of Quinte waters. Actual contaminant loads are unknown, although a bacteriological survey in 1984 confirmed that conditions were acceptable for swimming and bathing in the vicinity of Zwick's Island, and bacterial contamination from this source was minimal (Griffiths 1984).

6.1 FUTURE OF THE RAP

This Stage 1 Report identifies the key water quality issues in the Bay of Quinte AOC. The nine "Bay of Quinte Impaired Beneficial Uses" (Table 1 and Figure 40) can be summarized as five more general concerns:

1. the advanced eutrophic state of the bay;
2. localized bacteriological contamination;
3. heavy metals, persistent organics and toxics contamination;
4. loss of submergent and emergent wetlands, shoreline alterations, and loss of fish and wildlife habitat; and
5. an unbalanced ecosystem.

These concerns have been addressed by the Quinte RAP Coordinating Committee and PAC, employing a holistic, ecosystem approach. A two-part Stage 2 RAP report is currently being developed. Part 1 will describe some remedial options which can be addressed at this time and will seek, in principle, commitments to fund and implement the options, plus IJC acceptance of the plan, as described. Part 2 will identify the remaining "unknowns", data deficiencies and the studies required to define future remedial options, and provide the negotiated implementation commitments and schedules. Development of the two parts of the Stage 2 Report are described in the following sections.

6.1.1 Part 1 - Remedial Options

Water quality changes as a result of eutrophication and, to a lesser extent, bacterial contamination have been researched and documented, and a range of remedial options and supporting technical information has been presented to the stakeholders and public. Consensus for the preferred options will be determined from this information exchange and will comprise Part 1 of the Bay of Quinte RAP Stage 2 document.

Options available for stakeholder and public discussion to reduce eutrophication include:

1. improved phosphorus removal at STPs discharging directly to the bay, inland STPs and industrial plants;
2. treatment of water treatment plant filter backwash and sludge discharge;
3. improved agricultural practices;
4. inactivation of bay sediments;
5. corrections and/or improved operation of urban storm and sanitary sewage collection systems; and
6. increased water flow to enhance the dilution capacity and the flushing rate of the bay.

Bacteriological problems will be addressed, in part, through options 3 and 5 but will require further study to identify corrective measures as outlined under Section 6.1.2.3.

6.1.2 Part 2 - Information Deficiencies

6.1.2.1 Heavy Metals and Toxic Contaminants

Dredging of sediments and the consumption of some size classes of some fish species have been restricted in the Bay of Quinte because concentrations of heavy metals and toxic contaminants exceed federal and/or provincial guidelines. Precise loadings and the source (or sources) of these pollutants have not been identified. As outlined in this report, sources could be inside or outside the AOC, and specific sources within the Bay of Quinte have either been subject to recent control measures (see Section 5.1.2) or, as in most cases, their significance has not been determined. Consequently, additional remedial actions to combat contaminant loadings must be based on improved loading/contaminant data and a better understanding of the overall problem. While the information is being developed, the provincial MISA initiative will be employed to deal with direct toxic contaminant discharges. Under MISA, municipal and some industrial discharges will be

monitored and the effluents characterized. These data will provide the basis for improved estimates of point source loadings. RAP actions being undertaken to complement the MISA undertaking include:

1. development of a "Fate-Transport" model in 1989/90, to assess the major pathways of contaminant transport and transformation, as well as the environmental implications of existing and future loadings of these contaminants; and
2. development of a prioritized and coordinated five year research program to increase understanding of toxic contaminants in the Bay of Quinte ecosystem, and to assist in identifying and designing remedial actions in this regard.

6.1.2.2 Shoreline Alterations - Wetland Destruction

Shoreline alteration often translates into destruction and/or loss of emergent and submergent wetlands, and related impacts on fish and wildlife values. However, the extent of these changes is not fully appreciated, nor is there sufficient understanding to develop an appropriate shoreline development strategy. Bay of Quinte RAP actions will include:

1. in 1990, compiling the existing data bases into a GIS to improve access to this information and assist in coordinating shoreline planning;
2. comparing shoreline use and the habitat preferences of different sports fish;
3. documenting shoreline and land use alterations to assess recent wetland changes; and
4. assessing unproductive wetland areas for management (and scientific research).

6.1.2.3 Bacteriological Contamination

Numerous sources of bacterial contamination have been identified. Generally, these sewage discharge points are located within the municipalities and include: (1) combined sewer overflows; (2) bypassing at the STPs; (3) inflow

and infiltration within the collection system; (4) illegal connections to the collection systems; and (5) urban land runoff. Other sources are agricultural and include land runoff and poor livestock management.

Potential remedial actions have been discussed by the Bay of Quinte RAP Coordinating Committee and the PAC, and include some of the options described in Stage 1. However, further studies will be required to fully identify sources, corrective actions and costs. In Stage 2, the level of water quality - in this case, the number of beach closures due to bacterial contamination - will be outlined along with the preferred remedial actions. The options, as selected, will require additional work to identify costs and environmental effects. Existing funding mechanisms under various federal-provincial programs will be used to complete the task.

6.1.2.4 Unstable Ecosystem - Ecosystem Management

Nicholls and Hurley (1989) hypothesized that phytoplankton densities in the Bay of Quinte were determined, in part, by food chain factors, and that water quality improvements may depend largely on managing the influential food chain components. To what degree these internal elements control the aquatic communities of the bay and the processes required to manage (or artificially manipulate) and regulate the commanding food chain component(s) are unknown. Hence, no specific actions for ecosystem management are provided. Instead, the Bay of Quinte RAP Coordinating Committee will recommend in Stage 2 that this undertaking, including investigations to identify remedial options, be part of the five-year research program.

6.1.3 Conclusion

As noted, the Stage 1 Report summarizes the key water quality concerns in the Bay of Quinte. Nine impaired beneficial uses and five general pollution problems were identified. Wherever possible, corrective actions, data deficiencies and further research needs have been described.

Stage 2 will be completed in two parts. Part 1 will comprise the preferred remedial actions without financial commitment for those impaired uses which can be immediately addressed, given the present level of scientific and technical understanding. Part 2 will describe the actions needed to address the "unknowns", identify future remedial actions, confirm commitments and implementation schedules, and set out monitoring and surveillance requirements.

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APPENDICES

APPENDIX A. Chronology of Public-Stakeholder Participation, Bay of Quinte Remedial Action Plan (Updated to February 28, 1990).

DATE	EVENT
Sept. 5 - 15, 1986	Identification of possible stakeholders using in-house sources.
Sept. 19	Initial contact with stakeholders identified in the preceding step via a letter. This letter outlined, generally, the RAP process, introduced the Coordinating Committee, and asked interested parties to register with the Committee by October 15, 1986.
Sept. 22 - 23	A workshop of technical and managerial staff from federal and provincial agencies convened in Belleville to discuss initially the goals and objectives of the Bay of Quinte RAP and the public participation component.
Oct. 1	Public announcement of Bay of Quinte RAP in Belleville Intelligencer, Napanee Beaver, Picton Gazette and Trenton Trentonian. This advertisement was approximately 10 X 8.5 cm, and it described the purpose of the RAP and asked interested parties/individuals to register with the Coordinating Committee by October 15, 1986.
Oct. 15	Initial stakeholder list compiled, and registration with the Coordinating Committee acknowledged by letter.
Oct. 15 to present	Ongoing expansion of stakeholder list following the advice of other government agencies and registered stakeholders.
Nov. 6, Nov. 15, and Nov. 20	A letter explaining the Coordinating Committee's intent, and a short (5 page) summary of events describing the RAP process, proposed goals and objectives of the Quinte RAP, and stakeholder involvement was mailed to registered stakeholders. Also, a questionnaire was distributed with the summary in an effort to (1) gather initial public response and (2) expand the RAP goals to reflect accurately public concerns. Responses to this questionnaire were submitted by November 30, December 15 and December 20, respectively.
Nov. 25	Glenn Owen presented talk to Rotary Clubs of Quinte region regarding Quinte RAP.

Dec. 1 Initial compilation of questionnaire responses by Michael Michalski Associates (contracted RAP report writer).

Dec. 8 Stakeholder list updated and all new members acknowledged and updated to events by letter.

Dec. 9 Coordinating Committee finalized program for stakeholder participation component.

Dec. 15 Initial information gathering phase completed, and stakeholders informed by letter of forthcoming Progress Report and January 28, 1987 public meeting.

Dec. 20 Analysis of questionnaire responses completed by Michael Michalski Associates and included in Progress Report.

Jan 12, 1987 Stakeholder list updated.

Jan. 14 Progress Report (Popularized version December, 1986) mailed to public.

Jan. 19 A letter, an agenda and a sketch map outlining the date and time, location, purpose and goals of public meeting forwarded to stakeholders. Stakeholders wishing to present oral briefs summarizing their concern(s) to the Coordinating Committee were asked to register with the Committee by January 26, 1987 and to submit a written brief on their position.

Jan. 20 - 26 List of stakeholders preparing briefs compiled.

Jan. 20 Press release of Progress Report and upcoming public meeting mailed by courier to:

- Belleville Intelligencer;
- Cablevue (Quinte) Ltd., Belleville;
- CFB Trenton Contact;
- CHEX Radio, Peterborough;
- CIGL-FM and CJBQ Radio, Belleville;
- CJTA Radio, Trenton;
- CKWS Radio and TV, Kingston;
- Kingston Whig-Standard
- Quinte Cablevision, Picton;
- Napanee Beaver;
- Picton Gazette;
- Trenton Trentonian and Tri-County News; and
- Shopper's Market Newspaper.

Jan 20 Coordinating Committee Chairperson and Public

	Liaison member interviewed by Belleville Intelligencer and Picton Gazette concerning RAP and public meeting.
Jan. 23 and Jan. 26	Advertisement of public meeting in Quinte region and Kingston newspapers. Notice was approximately 25 cm X 2 columns wide, and it ran for one printing day in each newspaper.
Jan. 28	Public meeting in Belleville.
Jan. 29	Media coverage of January 28th meeting including CKWS - TV (Kingston), CJBQ - Radio (Belleville), Picton Gazette, Trenton Trentonian, and the Belleville Intelligencer.
Feb. 1	Stakeholder list updated to include sign-ups from meeting, and all enquiries from this event responded to.
Feb. 9	Press coverage of Quinte Environmental Group in Trenton Trentonian.
Feb. 20	A letter and questionnaire to determine stakeholder attendance and input at public meeting, and comprehension of information distributed mailed to all stakeholders.
March 1	Stakeholder list mailed to Mr. Ernest Cornford.
March 30	Responses to questionnaire (Feb. 20) compiled and comments summarized.
April 13	List of public consultation consultants mailed to Mr. E. Cornford.
April 28	Coordinating Committee Chairperson spoke to Prince Edward District Women's Institute, Bloomfield.
May 6	Coordinating Committee Chairperson interviewed by the Centre for Great Lakes for a feature article to appear in their <u>Great Lakes Update Bulletin</u> .
May 6	<u>Bay of Quinte Remedial Action Plan: Progress Report (Feb. 1987)</u> mailed to stakeholders and presented to the press.
May 7	Coordinating Committee Chairperson appeared on open line radio talk show (CJBQ - Belleville) to discuss the Quinte RAP.
May 13	Interview taped for radio CJTM - Trenton

concerning the Quinte RAP and the Progress Report.

June	Stakeholder mailing list sent to Great Lakes United for their upcoming workshop on public participation with the RAP process.
July	<u>Great Lakes Reporter</u> article mailed to the stakeholders.
July	Quinte Update Newsletter (Vol 1) released to public and mailed to the stakeholders. The Newsletter included general description of the RAP process and stakeholder involvement, results of a questionnaire, public comments and concerns, some planned summer activities (information booth at local fairs) and an invitation to participate.
July 17-19	Information booth at the Quinte Waterfront Festival, Belleville. The booth was well received with approximately 200 people passing through and 20 names added to the mailing list.
August 1-3	Information booth at the Napanee Fair, Napanee. The booth attracted over 200 people and 40 new names were added to the mailing list including the area member of parliament.
August	Concerns expressed at the fairs addressed by the Committee - Kingston Office or forwarded to proper department/agency.
August 17	Secretary, RAP Coordinating Committee interviewed by Stewart Smith, <u>Loyalist Country Living</u> (Napanee) on the Quinte RAP mainly on agricultural matters and how they relate to the RAP program.
August 18	Secretary, RAP Coordinating Committee interviewed by Allan Capon, <u>Kingston Whig-Standard</u> (Picton Bureau) regarding the Great Lakes Reporter article and recent action by the Coordinating Committee.
August 20	Secretary, RAP Coordinating Committee interviewed by Bill Whitelaw, <u>Belleville Intelligencier</u> , Belleville regarding summer activities and upcoming events for the Quinte RAP. Information provided included: research and contracts presently underway, information booth and Quinte Update Newsletter, and other related information (Ault Foods, Napanee sewage treatment plant and Belleville Sewer Study)

August 20	Mailing list updated
Sept. 3	Letter to stakeholders describing purpose, time and location of upcoming public meeting as well as an outline of the terms of reference for the proposed socio-economic study.
Sept. 11 - 13	Information booth at the Picton Fall Fair, 219 people visited the booth, and 30 names were added to the mailing list.
Sept. 16 - 20	Information booth at the Quinte Exhibition, Belleville. 280 people visited the booth, and 36 names were added to the mailing list.
Sept. 20	Mailing list updated - over 350 people included as stakeholders.
Sept. 22	Public meeting - Belleville and District Fish and Game Club, Belleville. The proposed socio-economic study was discussed. As well, a forum for questions from the public was provided -- major concerns related to actions, public consultation, landfills, and the RAP completion date.
Sept. 30	Stakeholder list updated - 375 stakeholders
October	Coordinating Committee Chairperson discussed the Quinte RAP at a meeting of the Y's Mens Club, Belleville.
Oct. 28	Quinte Environmental Resources Association (QERA) holds initial organizational meeting in Belleville. Coordinating Committee Chairperson attended.
Oct. 30	Mailing to stakeholders inviting each to attend a public meeting on November 18. Included was the proposed terms of reference for a Public Advisory Committee (PAC).
Nov. 6	Advertisement in the Picton Gazette regarding the upcoming public meeting for establishing a PAC.
Nov. 9	Coordinating Committee Chairperson addressed the St. Lawrence Council regarding the RAP process and Areas of Concern.
Nov. 10	Mailing to stakeholders who attended the September 22 meeting; documentation of their concerns and questions with the Coordinating

Committee responses.

Nov. 12 Coordinating Committee Chairperson addressed Queen's Student Pugwash Meeting in Kingston.

Nov. 16 Kingston Whig-Standard, Advertisement for public meeting.

Nov. 18 Public meeting held at the Belleville and District Fish and Game Club. Coordinating Committee Chairperson and David Evans (Manager, Public Consultation and Information) were present. Discussion on formation of a PAC. Terms of reference for a facilitator and the PAC were tabled. The facilitator to be hired immediately by the RAP team. PAC terms of reference subject to revisions once the PAC is established. 40 stakeholders present.

Nov. 19 Coordinating Committee Chairperson interviewed by Bill Whitelaw, Belleville Intelligencier regarding the public meeting and the PAC.

Nov. 19 Coordinating Committee Chairperson interviewed by Shelley Sears, CJBQ Radio, Belleville regarding the public meeting and a PAC.

Nov. 26 Coordinating Committee Chairperson and Jim Bishop (Director, Water Resources Branch) provided address about the Bay of Quinte RAP and the RAP process in general, at a joint meeting of the Soil Conservation Society of America and the Canadian Water Resources Association.

Dec. 7 Secretary, Coordinating Committee provided a presentation-talk to the Decisions for the Great Lakes environmental group, Queen's University, Kingston outlining four aspects of the RAP: a general background to Areas of Concern and the RAP process; the Quinte RAP problems and possible remedial options; MISA and the needed connection to RAP; and Quinte RAP public consultation and education - pitfalls, shortcomings, experiences and new directions.

Dec. 8 Coordinating Committee Chairperson interviewed by Julie Whitmore, Centre for the Great Lakes on Quinte RAP public involvement program, as well as, issues in the Bay of Quinte.

Dec. 8 Coordinating Committee Chairperson interviewed by Donna Skelly, CKWS Radio, Kingston on the Bay of Quinte RAP.

Dec. 9 2nd Newsletter mailed to stakeholders. Information was provided on the 1987 technical work underway and completed.

Dec. 14 Facilitator, Jan Samis selected to form and coordinate a PAC.

Dec. 15 Telephone survey of 25 stakeholders to solicit their comments on selection of J. Samis as facilitator. 96% of those surveyed agreed with selection - J. Samis hired.

Dec. 16 Secretary, Coordinating Committee outlined RAPs, water quality in general, environmental education and other environmental issues to a Grade 8 environmental studies class, Kingston.

Jan. 4, 1988 Letter and information pertaining to development of the Lake Ontario Toxics Management Plan sent to all stakeholders.

Jan. 14 Coordinating Committee chairperson provided a Quinte RAP Update at the Southeast Region Administration Meeting.

Jan. 21 Public meeting of PAC, Trenton. Initial setup and sectors to be represented, membership and size of PAC determined.

Jan. 22 Secretary, Coordinating Committee interviewed by Pamela Miller, Pollution Probe, Toronto regarding public consultation processes with the Quinte RAP. Verbally provided background on recent events, formation of PAC, etc. Also forwarded package of Quinte RAP past undertakings (Progress Report).

Feb. 10 Coordinating Committee Chairperson provided background information regarding RAPs to the Richmond and Tyendinaga Resources Association.

Feb. 16 Stakeholder list updated.

Feb. 17 Secretary, Coordinating Committee Chairperson interviewed by Tom Adams, Centre for the Great Lakes, Toronto about the progress of the RAP, schedule, public consultation, recent events and communications.

Feb. 17 PAC meeting Picton. Coordinating Committee Chairperson provided background information on RAPs and the problems in the Bay of Quinte.

Feb. 19 3rd Newsletter ("Good News Newsletter") mailed

to stakeholders.

March 24	PAC Meeting, Napanee - Secretary, Coordinating Committee attended. Discussion of impaired beneficial uses. A. Crowder, Queen's outlined the role of wetlands.
March 30	Invitation to all stakeholders to attend John Hartig talk on 42 RAPs.
April 12	PAC meeting, John Hartig talk on RAPs.
April 18	Ecosystem modelling workshop attended by scientists, managers, PAC members and stakeholders and held in Kingston from April 18 to April 20.
April 28	PAC meeting. Secretary, Coordinating Committee presented the highlights of the "Point Source Discharge" technical background report.
May 12	Three technical background reports: <u>The Evaluation of Toxic Contaminants; Point Source Discharges;</u> and, <u>Increasing the Hydrologic Flushing Rate</u> hand delivered to Belleville and Napanee Public Libraries.
May 12	Technical report <u>Increasing the Flushing Rate of the Upper Bay</u> mailed to local newspapers and local conservation authorities.
May 16	Three technical background reports (as above) mailed to Trenton, Deseronto and Picton Public Libraries.
May 16	Mailing list updated.
May 19	Ken Minns (Department of Fisheries and Oceans) presented <u>Increasing the Upper Bay Flushing Rate</u> to PAC at meeting in Deseronto.
May 19	Three Quinte RAP technical background reports plus outline of 88 contaminant survey presented to PAC members for their review and information.
May 20	Two Quinte RAP technical background reports mailed to local newspapers.
May 24	Three technical background reports mailed to five municipalities around the Bay.
May 30 - June 4	Public display booth at the Quinte Mall - Belleville during Environment Week.

June 2 Secretary, Coordinating Committee interviewed by Shirley Langer (Quinte Environmental Resources Association) and Lee Jourard (Cablevue Quinte Ltd.) concerning the education component of the Quinte RAP.

June 7 Coordinating Committee Chairperson forwarded Quinte RAP information to the Federation of Ontario Naturalists (FON).

June 9 Coordinating Committee Chairperson forwarded Quinte RAP information to the Northeast - Midwest Congressional Coalitions's Status Report on RAPs.

June 16 Technical background reports mailed to CKWS-TV (Kingston) and CJOH-TV (Ottawa).

June 20-23 Ecosystem Modelling Workshop. Participants included 4 PAC members, PAC Facilitator, Industry representative (Domtar) and scientist-technicians from various federal and provincial agencies.

June 21 Don Poulton gave presentation to PAC highlighting the findings of the Toxic Contaminant Study.

July 13 Centre for the Great Lakes "FACT SHEET - BAY OF QUINTE" plus introductory letter by Coordinating Committee Chairperson mailed to stakeholders.

July 15-17 Information booth at Belleville Waterfront Festival.

July 18 Quinte Update - Newsletter #4 - July, 1988 mailed to stakeholders.

July 23 PAC boat tour of the upper bay of Quinte to witness firsthand areas of pollution concern and degradation.

July 30-Aug. 1 Display booth at the Napanee Fair, Napanee - unmanned; new names for stakeholder list.

Sept. 6 IJC Focus magazine mailed to stakeholders with article on Quinte RAP authored by Coordinating Committee Chairperson.

Sept. 9-11 Display booth at the Picton Fair, manned Sunday, September 11. 30 names added to stakeholder list.

Sept. 12 PAC members provided with draft reports:

Feasibility of Decreasing Sediment P Release and
Diffuse Agricultural Sources of Nutrients for
PAC review and comment.

- Sept. 14 Coordinating Committee Chairperson spoke about the Quinte RAP with the Lions Club of Kingston.
- Oct. 1-2 Public display booth, unmanned, at the Ameliasburgh Township Fair. 20 new stakeholders identified.
- Oct. 6 PAC Workshop, Belleville. Coordinating Committee Chairperson and Larry Matheson, Ontario Ministry of Agriculture and Food, provided highlights and discussed the Ecosystem Modelling report and the Diffuse Agricultural Sources report respectively.
- Oct. 15 Jan Samis, PAC Facilitator, interviewed by Loyalist College TV, Belleville, about RAP.
- Oct. 20 Coordinating Committee Chairperson presented outline of the Bay of Quinte RAP and RAPs in general to Grade 13 Environmental Studies Class, Centennial High School, Belleville.
- Oct. 22 Quinte RAP public information booth manned at the Underwater Film Festival in Belleville.
- Oct. 23 Mailing to stakeholders. Invitation to attend lecture by Dr. J. Vallentyne of the International Joint Commission in November.
- Nov. 9 Jack Vallentyne discussed "The Individual's Role in Environmental Clean-Up", to approximately 125 stakeholders in Belleville. Quinte RAP information booth manned.
- Nov. 10 Coordinating Committee Chairperson presented RAP process to the Abatement and Utility Operations staff of the Southeastern Region of the Ministry of the Environment.
- Nov. 30 PAC meeting, Deseronto. Coordinating Committee Chairperson discussed some contaminant survey findings, especially dioxins in fish near Trent River.
- Dec. 1 Coordinating Committee Chairperson provided talk to Gananoque Lions Club.
- Dec. 5 Secretary, Coordinating Committee outlined the RAP process and highlights of the Quinte RAP at Ernestown Secondary School Environmental

May 23 Coordinating Committee Chairperson spoke to Belleville Kiwanas Club.

May 25 Secretary, Coordinating Committee spoke to the Frontenac Pistol and Gun Club - Kingston.

June 12 PAC meeting to discuss draft Options Report, Public Consultation (Video) and Socio-economic work. Tom Huff, Reptilian Foundation - Picton presented talk on reptiles around the bay. Technical Report #7 - Controlling Release of Phosphorus from Sediments - presented to PAC members. Coordinating Committee Chairperson and Secretary in attendance.

June 13 Secretary, Coordinating Committee discussed RAP with Shannonville Women's Auxiliary. The presentation centred on "What You the Individual can do to Help".

June 19 Secretary, Coordinating Committee outlined RAP to Gananoque Secondary School - Environmental Studies course.

June 22 PAC met to discuss information distribution techniques. Coordinating Committee Chairperson and Secretary in attendance. New analytical data released on dioxins in walleye.

June 27 Press release - "Dioxins in Bay of Quinte Walleye Below Federal Guidelines".

July 14 - 16 Public information booth staffed at Belleville/Quinte Waterfront Festival and Folklarama.

July 28 - 30 Public information booth staffed at Trenton Bathtub Days.

August 5 - 7 Public information booth maintained at Napanee Fair.

August 6 Murray German discussed Quinte RAP at SEEDS Conference (i.e., teachers trying to incorporate environmentl teachings in the classroom) in Kingston.

September 5 Notice of press conference regarding "Time to Decide - A Discussion Paper"; notice of meetings mailed to press.

September 7 Notice/invitation of public open houses mailed to sectors and stakeholders (1400).

September 8 - 10 Public information booth staffed at Picton Fair.

September 18 Press conference - Belleville to announce release of "Time to Decide - A Discussion Paper".

September 18 Fred Stride interviewed by Andy Barrett, Kingston CKWS-AM Radio about press conference.

September 18 Glen Hudgin, PAC Chariman interviewed by CJBQ-AM Radio and Trenton and Peterborough TV.

September 19 "Time to Decide - A Discussion Paper" mailed to stakeholders and invitees (approximately 1400).

September 20 Fred Stride interviewed by CKMS-FM Radio Kingston about release of "Time to Decide - A Discussion Paper".

September 20 Full page ad placed in Napanee Beaver and Picton Gazette advertising public open houses.

September 26 Public open house, Napanee to discuss "Time to Decide - A Discussion Paper". All day event, approximately 150 people attended.

September 27 Public open house, Picton, (as above)

October 2 Fred Stride and Kathy Vowinckel (Alternate Chairperson - PAC) participated on radio phone-in talk show, CJBQ-AM Radio, Belleville.

October 4 Public open house, Trenton, (as above).

October 5 Public open house, Belleville, (as above).

October 6 Fred Stride discussed RAP with Napanee Chapter of Canada World Youth.

October 11 Fred Stride participated in Environmental Day at St. Paul's Secondary School, Trenton. Quinte RAP in context of student input and involvement was discussed and video shown.

October 12 - 13 Four members of PAC and ^{one} RAP team member attended IJC Conference on Hamilton.

October 15 Fred Stride provided tour of Quinte STPs and WTPs to Queen's Graduate Environmental Studies class.

October 18 PAC meeting to discuss program for "Option Selection"; Murray German and Fred Stride attended. Also, Tom Coape-Arnold presented aspects of the Lake Ontario Toxic Management Plan and its implicatiosn to RAPs.

October 20	Video and discussion presented by Fred Stride to Queen's University microbiology class.
October 21	Video and public information booth, Environmental Day, Joyceville Public School, manned by Murray German
October 23	Video and discussion presented by Ken Minns to Queen's University (Graduate Biology Economics Program).
October 24	Video and talk presented by Fred Stride to Napanee Kinsmen Club.
October 25	Video and talk presented by Fred Stride to Environmental Studies class, Centennial High School, Belleville.
November 29	PAC sponsored public hearing in Belleville. Briefs on remedial options described in "Time to Decide - A Discussion Paper" received from public and stakeholders. Approximately 40 oral and 25 written briefs received.
January 9, 1990	Presentation to Bloomfield United Church Man's Club by Murray German.
January 9	Video "Time to Decide - A Discussion Paper" viewed by Picton Tourist Association.
January	Video loaned to City of Trenton, Town of Picton, Loyalist College - Belleville, Deep Quest II Explorations (Diving and Aquatic Research), and Quinte Environmental Resources Association (QERA).
January 10	Murray German discussed Quinte RAP with Belleville Newcomers Club.
January 11	Murray German participated in Radio Talk Show Interview, Kingston.
January 12	Murray German provided RAP information to Kingston Kiwanis Club.
January 15	Draft PAC "Summary of Preferred Remedial Options via Public Consultation Process" received by Coordinating Committee.
February 15	Two member of PAC attended Great Lakes United Conference, Buffalo.

February 26

Murray German and Fred Stride participated in Public School Teachers Professional Development Day (i.e., Incorporating the environment into school curriculum in Belleville).

APPENDIX B

Summary of media coverage, Bay of Quinte Remedial Action Plan (updated to June 28, 1989)

DATE	EVENT
Sept. 19, 1986	Press coverage of RAP (Bill Whitelaw interviewed Glenn Owen) in Belleville Intelligencer, "Federal-Provincial Committee wants Public to Help: Better Bay Water to be Explored". Coverage included a contact address.
Sept. 30	Press coverage of the RAP in Kingston Whig-Standard, "Briefs Sought on Water Quality in Bay of Quinte". Coverage included a contact address.
Oct. 1	Public announcement of Bay of Quinte RAP in Belleville Intelligencer, Napanee Beaver, Picton Gazette and Trenton Trentonian. This advertisement was approximately 10 X 8.5 cm, and it described the purpose of the RAP and asked interested parties/individuals to register with the Coordinating Committee by October 15, 1986.
Jan 20, 1987	Press release of <u>Progress Report</u> and upcoming public meeting mailed by courier to: . Belleville Intelligencer; . Cablevue (Quinte) Ltd., Belleville; . CFB Trenton Contact; . CHEX Radio, Peterborough; . CIGL-FM and CJBQ Radio, Belleville; . CJTA Radio, Trenton; . CKWS Radio and TV, Kingston; . Kingston Whig-Standard; . Quinte Cablevision, Picton; . Napanee Beaver; . Picton Gazette; . Trenton Trentonian and Tri-County News; and . Shopper's Market Newspaper.
Jan. 21	Press coverage in Belleville Intelligencer, "Bay's Quality: Action Plan to Public".
Jan. 23	Interview by telephone between Coordinating Committee Chairperson and Trenton Trentonian.
Jan. 23 and Jan. 26	Advertisement of public meeting in Quinte region and Kingston newspapers. Notice was approximately 25 cm X 2 columns wide, and it ran for one printing day in each instance.
Jan. 29	Media coverage of January 28th meeting including CKWS - TV (Kingston), CJBQ - Radio, (Belleville), Picton Gazette, Trenton Trentonian, and the Belleville Intelligencer.

Feb. 9 Press coverage of Quinte Environmental Group in Trenton Trentonian.

May 1 Press coverage of Coordinating Committee Chairperson's talk in Bloomfield presented in the Picton Gazette.

May 6 Coordinating Committee Chairperson interviewed by the Centre for Great Lakes for a feature article to appear in their Great Lakes Update bulletin.

May 7 Coordinating Committee Chairperson appeared on open line radio talk show (CJBQ, Belleville) to discuss the Quinte RAP.

May 7 Interviews with the Belleville Intelligencer (Bill Whitelaw) and the Trenton Trentonian (Ron Gibson) regarding release of the Progress Report.

May 9 Press coverage in the Belleville Intelligencer.

May 11 Press coverage in the Trenton Trentonian.

May 11 Coordinating Committee Chairperson interviewed by Picton Gazette (David Cox) concerning Progress Report.

May 13 Interview taped for radio CJTM - Trenton concerning the Quinte RAP and the Progress Report.

May 15 Newspaper articles, Napanee Beaver, announcing opening of \$3million sewer system connecting Tyendinaga Reserve to the Deseronto collection system.

May 20 Press report in the Picton Gazette.

May 87 Press coverage by Centre for the Great Lakes, Chicago in the Great Lakes Reporter (Vol 4(2)) entitled "Scenic Bay of Quinte Seeks Solution to Phosphorus Problem".

Aug. 7 Press coverage in Trenton Trentonian, "Water Study says Bay Problem Area".

Aug. 17 Secretary, Coordinating Committee interviewed by Stewart Smith, Loyalist Country Living (Napanee) on the Quinte RAP mainly on agricultural matters and that relation to the RAP program.

Aug. 18 Secretary, Coordinating Committee interviewed by Allan Capon, Kingston Whig-Standard (Picton Bureau) regarding the Great Lakes Reporter article and recent action by the Coordinating Committee.

Aug. 20 Secretary, Coordinating Committee interviewed by Bill Whitelaw, Belleville Intelligencer, Belleville regarding

summer activities and upcoming events for the Quinte RAP. He indicated that a feature article summarizing the Quinte RAP was forthcoming. Information provided included: research and contracts presently underway, information booth and Quinte Update newsletter, other related information (Ault Foods, Napanee STP, and Belleville Sewer Study).

- Aug. 21 Article in the Belleville Intelligencer called "Studies Now Underway to Cut Bay Phosphorus".
- Sept. 87 Article "The Sad Plight of the Bay of Quinte" in the Loyalist Country Living.
- Sept. 10 Press coverage in the Belleville Intelligencer entitled "Bay Study this Fall, Needs Input from Public".
- Sept. 16 Newspaper article "Phosphorus Levels Found on the Rise in Bay of Quinte" in the Kingston Whig-Standard.
- Sept. 16 Newspaper article in the Trenton Trentonian entitled "Quinte Water to be Topic for IJC Sessions".
- Sept. 17 Newspaper article in the Belleville Intelligencer entitled "Criticism Surprises Bay Study Chairman".
- Oct. 30 News item, Trenton Trentonian, "Quinte Environment First Priority for Public Group. Article pertaining to Quinte Environmental Resources Association (QERA), lists their objectives, purpose, structure and priorities.
- Nov. 6 Advertisement in the Picton Gazette regarding the upcoming public meeting for establishing a PAC.
- Nov. 9 Press coverage, Trenton Trentonian, "Action Group May Form Advisory Committee", advising public meeting to form PAC.
- Nov. 11 Belleville Intelligencer, "Quality of Bay Water Target of Committee".
- Nov. 16 Kingston Whig-Standard, advertisement for public meeting.
- Nov. 19 Coordinating Committee Chairperson interviewed by Bill Whitelaw, Belleville Intelligencer regarding the public meeting and the PAC.
- Nov. 19 Coordinating Committee Chairperson interviewed by Shelley Sears, CJBQ Radio, Belleville regarding the public meeting and a PAC.
- Nov. 20 Newspaper article in the Picton Gazette, "RAP Response to Stakeholders' Concerns". This article described the Coordinating Committee replies to stakeholder enquiries presented at the September 22, 1987 public meeting.

Nov. 20 Belleville Intelligencer, "Committee Coordinates Water Concerns", describes RAP processes in detail.

Nov. 25 Newspaper article in the Kingston Whig-Standard, "Bay of Quinte Remedial Group Sets Up Public Committee". Article pertained to the public meeting in Belleville, November 18 to establish a PAC.

Nov. 25 Newspaper article in the Picton Gazette, "Public Advisory Committee for RAP to be Established". The article pertained to the public meeting in Belleville, November 18 to establish a PAC.

Nov. 27 Article in Trenton Trentonian about Quinte Environmental Resources Association, scope of mandate.

Nov. 28 Article in the Trenton Trentonian regarding Domtar program to clean-up leacheate to the Trent River and corresponding public meeting.

Nov. 30 Article in Trenton Trentonian about QERA, 2nd meeting, defining members and role of QERA in RAP.

Dec. 8 Coordinating Committee Chairperson interviewed by Julie Whitmore, Centre for the Great Lakes on Quinte RAP public involvement program, as well as, issues in the Bay of Quinte.

Dec. 8 Coordinating Committee Chairperson interviewed by Donna Skelly, CKWS Radio, Kingston on the Bay of Quinte RAP.

Dec. 31 News article, Trenton Trentonian, "Resource Group Gets Ministry Link". Report announcing hiring of Jan Samis as facilitator. Also, some QERA activities were outlined.

Oct/Nov/Dec The Great Lakes Reporter, Coordinating Committee Chairperson interviewed in the article "Remedial Action Plans Attack Areas of Concern - Ontario/Canada Stress Public Consultation Investment".

Jan. 8, 1988 News article, Kingston Whig-Standard, "Cement Plant Charged with Discharging Contaminants". Charges laid against Lake Ontario Cement, Picton.

Jan. 13 News article, Picton Gazette, "Toxics Management Plan Shares Concerns of RAP". Outline of the Management Plan objectives and its link to RAP.

Jan. 13 News article, Picton Gazette, "Rap Public Advisory Committee to be Established at Jan. 21 Meeting". Interview with Jan Samis, advertising PAC and its purpose.

Jan.13 News article, Picton Gazette, "Lake Ontario Cement Charged

Under EPA".

Jan. 13 News article, Trenton Trentonian, "Public Advisory Committee Planned for Quinte Action Plan Group". Interview with Jan Samis outlining PAC and its role.

Jan. 14 News article, Napanee Beaver, "Environmentally-minded People Sought to Sit on Advisory Committee". Interview of Jan Samis; call for help to form PAC.

Jan. 19 News article, Belleville Intelligencer, "Water Quality Committee Forming", announcing the PAC formation and summary of Jan Samis interview.

Jan. 27 Newspaper article, Picton Gazette, "RAP Public Advisory Committee Includes County Representation". Outlines the PAC membership.

Feb. 3 Newspaper article, Napanee Beaver, "Local Input Assured with RAP PAC".

Feb. 17 Secretary, Coordinating Committee interviewed by telephone by Tom Adams, Centre for the Great Lakes, Toronto about the progress of the RAP, schedule, public consultation and information dissemination.

Feb. 19 Newspaper article, Kingston Whig-Standard, "Official: Doing Nothing and Letting Nature Clean Bay May Be Best". Highlights of Murray German presentation at Quinte RAP PAC meeting.

Feb. 19 Newspaper article, Belleville Intelligencer, "Action Plan Battling Bay's Problems".

Feb. 20 3rd Newsletter mailed.

Feb. 24 Picton Gazette, "RAP Committee Faced with Challenge to Clean-up Bay". Coordinating Committee Chairperson presentation to PAC.

March 9 Napanee Beaver, "Phosphorus from Sewage Treatment Plants Polluted Bay"; Coordinating Committee Chairperson presentation to PAC.

March 24 Belleville Intelligencer, "Students Tackle Bay's Pollution Problem This Summer". Dr. A. Crowder speaks to PAC.

April 5 Kingston Whig-Standard, advertisement to John Hartig (IJC) talk at PAC meeting April 11, Belleville.

April 8 Belleville Intelligencer, article summarizing QERA activities in 1987.

April 11 Belleville Intelligencer, advertisement of John Hartig's

(IJC) talk that evening.

April 14 Belleville Intelligencer, "Bay of Quinte Clean-up Group Urged to Keep Public Informed", article outlining John Hartig's talk.

April 15 Trenton Trentonian, "Bay of Quinte Clean-up Has Hartig in Rapture".

April 20 Picton Gazette, "Grass Roots Participation Vital to RAP's Success: IJC Official".

May 2 Trenton Trentonian - "Bay a HOT SPOT - Quinte Clean-up to Cost \$5 Million", Secretary, Coordinating Committee's presentation on the Point Source Discharges Report.

May 2 Trenton Trentonian, "Bay Clean-up Plan Deadline Too Soon", PAC meeting discussion.

May 6 Ministry of the Environment press release, "Money to Picton for Sewage System Study".

May 13 Trenton Trentonian, "RAP Probes Phosphorus Clean-up", highlights flushing option.

May 13 Trenton Trentonian, "Toxic Discharge Control Cost Domtar \$2 Million", describes Domtar's cleanup proposal of blob in Trent River.

May 20 Belleville Intelligencer, "Flushing Bay Not Feasible Cleaning Idea - Scientist". Critique of K. Minns presentation of flushing option to PAC.

June 1 Picton Gazette, "RAP Study Examines Option of Increasing Flushing Rate of the Upper Bay of Quinte". Notification that this report and other technical reports are available in the local Quinte public libraries, etc.

June 2 Secretary, Coordinating Committee television interview with Shirley Langer (QERA) and Lee Jourard (Cablevue (Quinte) Ltd.) regarding past, present and future public education plans of the Quinte RAP.

June 7 Kingston Whig-Standard, "Pollution Studies Now in Libraries". Indicates that Quinte RAP technical background reports are available for viewing from the Quinte public libraries.

June 8 Napanee Beaver, "RAP Study Examines Option of Increasing Flushing Rate of Upper Bay of Quinte". Highlights of the flushing option report and notice that report is available from the local libraries for viewing.

June 14 Belleville Intelligencer, "Bay Group Starts Reviewing

Studies". Describes the contaminant study (Beak Consultants 1987).

- June 22 Belleville Intelligencer, "Bay Has Its Good and Bad Spots". Don Poulton presentation of Toxic Contaminants Study to PAC.
- June 24 Picton Gazette, "RAP Study Assembles Data Pertaining to Contaminants", as above.
- June 28 Napanee Beaver, "RAP Study Assembles Data Pertaining to Contaminant in the Bay of Quinte", as above.
- July 21 Glenn Owen interviewed by CKWS - TV News, Kingston on progress of the RAP, public participation and the role of the PAC.
- July 21 Information on toxic contaminants in the Bay of Quinte, plus all other RAP education information and reports sent to Pollution Probe, Toronto.
- July 22 Trenton Trentonian, "Action Plan for Bay Requires Public Input". Interview with Coordinating Committee Chairperson outlining the recent Quinte RAP highlights.
- July 23 Jan Samis interview on CKWS - TV regarding Quinte RAP and PAC Boat Tour.
- July 23 Jan Samis interviewed by CJBQ Radio, Belleville about Quinte RAP and PAC Boat Tour.
- July 25 Jan Samis interviewed by CJTN Radio, Trenton about Quinte RAP and PAC Boat Tour.
- July 25 Trenton Trentonian, "Input Sought".
- July 25 Belleville Intelligencer, "Boat Tour of Bay of Quinte Highlights Some Trouble Spots".
- July 26 Secretary, Coordinating Committee interviewed by Lynn MacDonald, M.P., Ottawa about costs and scheduling of the Bay of Quinte RAP.
- July 27 Trenton Trentonian, "Intense Development Makes Bay Restoration Difficult". Report on the PAC boat tour of the bay to witness firsthand some areas of obvious pollution concern and degradation.
- July 28 Kingston Whig-Standard, "Committee Looks at Bay Pollution Close-up", as above.
- July 28 Belleville Intelligencer, "Bay Pollution Clean-up Efforts Steaming Ahead", as above.

? Editorial, "Environment". Outlines local environmental activities and groups.

Sept. 16 Photo of public display booth at the Picton Fair.

Oct. 3 Trenton Trentonian, "Bay of Quinte Clean-up Plan Hits Snag", recent developments of RAP and advertising October 6 PAC workshop and agenda.

Oct. 11 Trenton Trentonian, "Farming Blamed for Phosphorus in the Bay of Quinte". Parts of Coordinating Committee Chairperson's presentation at the PAC Workshop October 6.

Oct. 17 Trenton Trentonian, "RAP Sets Shoreline Preservation as Priority for Bay of Quinte". PAC resolution to establish a single wetland authority to protect and rehabilitate wetlands.

Oct. 20 Kingston Whig-Standard, "Bay of Quinte Phosphorus Linked to Farm Erosion". Highlights of Coordinating Committee Chairperson's presentation at PAC workshop October 6.

Nov. 11 Trenton Trentonian, "Public Becoming Outraged at Biosphere Mistreatment", Jack Vallentyne's address to PAC and public.

Nov 16 Picton Gazette, "Canadian Scientist Pushes for Clean-up". Jack Valentyne's address in Belleville on November 9.

Nov. 30 Press release, "Dioxins found in whole body of four walleye (level below Ministry requirement for fillet off back) near Trenton", released to all local newspapers and radio stations at meeting of PAC.

Dec.1988 Great Lakes Reporter, "Areas of Concern - Port Hope, Quinte RAPs in the Works", ongoing information item in the Reporter.

Dec. 1 Belleville Intelligencer, "Traces of Poisons in Bay of Quinte Fish". Coordinating Committee Chairperson's presentation to PAC on discovery of dioxins in whole body samples of walleye taken near Trenton.

Dec. 1 Belleville Intelligencer, "Mohawks Plan to Govern Their Wetlands Themselves". Presentaton by Mohawks of the Bay of Quinte to PAC as to native position and participation on Quinte RAP.

Dec. 5 Trenton Trentonian, "Bay Clean-up Interest High Despite Setbacks" - Interview with Coordinating Committee Chairperson on Quinte RAP status.

Dec. 5 Trenton Trentonian, "Poisons Found in Area Walleye". Press release regarding whole body walleye containing

dioxins and furans found near Trent River.

Dec. 7 Picton Gazette, "Scientists Locate Dioxins in Bay of Quinte Walleye", as above.

Dec. 7 Picton Gazette, "Tyendinaga Mohawks Proclaim Themselves a Nation Committed to Protecting the Environment". Chief Earl Hill and Donny Maracle (Economic Development Officer) describe to PAC local native history and the Nation's position on environmental protection, the Quinte RAP and the proposed Quinte Wetland Authority.

Feb. 1, 1989 Picton Gazette, "PAC Makes Recommendations Regarding Bay of Quinte Contaminant Concerns". Summary of PAC meeting on this issue and their directives.

March 9 Belleville Intelligencer, "Computer Helps Plot Measures for Bay's Health". PAC meeting where computer model was demonstrated by Secretary, Coordinating Committee.

March 15 Picton Gazette, "RAP Computer Simulates Remedial Cleanup Actions", as above.

March 15 Picton Gazette, "Proposal for Public Questionnaire Ousted by Public Advisory Committee". PAC meeting discussion of options report - PAC decision to proceed.

April 7 Belleville Intelligencer, "New Pamphlet Outline Bay's Pollution Problems", PAC pamphlet described.

April 14 Picton Gazette, "Minister of Environment to Meet PAC Members", announcing Minister's visit.

April 17 Trenton Trentonian, "Coffee Cup Plan to Clean Up Bay of Quinte", highlights of April 11 PAC meeting and scoping out plans for public consultation for options.

April 19 Picton Gazette, "Public Involvement a Priority in Final Stages of Bay RAP", as above - details of public consultation for option selection.

April 21 Belleville Intelligencer, "Bradley Praises Local Efforts to Clean Up Bay of Quinte", highlights of Minister's visit plus comments from Jan Samis, PAC Facilitator.

April 24 Trenton Trentonian, "Bradley Praises Bay Committee for Clean Up Plan", Minister visit with PAC in Belleville indicating commitment to RAP, progress of PAC, MISA and recycling. Also, includes comments from Glen Hudgin (PAC Chair) and Chairperson, Coordinating Committee.

April 26 Picton Gazette, "Environment Minister Meets Public Advisory Committee", as above, plus Picton Reeve Clapp presenting Minister with Picton Harbour Study.

April 26 Trenton Trentonian - Editorial, "Bay Clean Up Plan Not Local Obligation", outlines need to clean up the bay and the rest of the Great Lakes; everyone is responsible.

May 17 Press release, "Dioxins in Walleye", sent to local newspapers and radio stations.

May 17 CJBQ-AM Radio, report on above with interview with Secretary, Coordinating Committee.

May 18 Belleville Intelligencier, "Lake Levels Rising but Bay will Stay Low". Environment Canada report on Great Lakes water levels with local comments from RAP.

May 24 Belleville Intelligencer, "Dangerous Chemicals Found in Area Pickerel". Report on dioxins found in walleye (88 samples, whole fish, actions to be taken).

May 24 Picton Gazette, "Presence of Dioxins in Bay Walleye Confirmed", as above.

May 26 Trenton Trentonian, "Pollutants Present in Bay of Quinte Walleye", as above.

May 27 Belleville Intelligencer, "Environmental Group urges Better Fish Toxins Alert". QERA response to dioxins in fish.

June 6 John Tooley, Ministry of the Environment Sub-Office, participated on radio talk show (CJBQ Belleville). MISA and RAP were described.

June 8 Secretary, Coordinating Committee interviewed by Toronto Star regarding dioxins in walleye.

June 9 Toronto Star, "Fish Sales Approved Despite Dioxin Fears".

June 9 Belleville Intelligencer, "Pickeral Story Taken Out of Context". Ministry of Natural Resources reaction to Toronto Star report.

June 12 Kingston Whig-Standard, "Fisheries Officials say Pickerel Harvest won't be Suspended", as above.

June 12 Toronto Star, "Sale of Dioxin Fish Angers Quinte Group". Reaction to dioxins and commercial fisheries.

June 13 Belleville Intelligencer, "Langer Not Telling People to Stop Eating Fish Caught in Bay of Quinte". QERA reaction to Toronto Star article June 9.

June 13 Belleville Intelligencer, "Snapping Turtles NOT Being Protected says Reptile Expert". Presentation by Tom Huff

to PAC, June 12.

- June 14 Trenton Trentonian, "Expert Warns Toxins Killing Turtles in Area". Presentation by Tom Huff, Reptile Breeding Foundation, Picton, to PAC June 12.
- June 16 Trenton Trentonian, "Public to Weigh Clean-Up Options for Quinte Water". PAC meeting June 12 about options paper.
- June 27 Press release, "Dioxin Levels in Bay of Quinte Walleye Below Federal Guidelines".
- June 28 Chairperson, Coordinating Committee contacted by press regarding press release above. Contacts include: Rob Tripp (Toronto Star); John Smith (Quinte News); David Clark (CKLC); Lisa Pappas (CKWS, CKMK).

APPENDIX C Terms of reference for the establishment of a Public Advisory Committee, Bay of Quinte Remedial Action Plan.

OBJECTIVES:

- . To provide public input to the development of the Bay of Quinte Remedial Action Plan, with respect to desired use goals of the water body and remedial options for achieving these goals; to ensure that the plan reflects the communities goals and objectives;
- . To provide effective representation of the community from interested groups or individuals through the make-up of the membership;
- . To advise and assist in the RAP public information and education program;
- . To provide a basis for generating broad community support for implementation of the final plan.

PURPOSE:

The Public Advisory Committee will work closely with the RAP team on key aspects of the Remedial Action Plan preparation and implementation. This includes, but is not limited to, goals of the plan, problems to be addressed, planning methodology, technical data, remedial action options, plan recommendations and implementation.

MEMBERSHIP AND REPRESENTATION:

General

Membership on the Public Advisory Committee shall attempt to include a wide range of representation from the study area. Membership shall include groups, agencies and individuals having direct effect on or being directly affected by the water quality of the Bay of Quinte, and can also include groups, agencies or individuals having an interest in the uses and management of the area who express an interest in participating.

It will be the responsibility of the Public Advisory Committee members to relay planning information and decisions to the groups or agencies they represent.

The Public Advisory Committee shall meet and determine rules of procedure, including frequency of meetings, time, location, etc., and shall review these rules of procedure with the RAP Team Co-ordinator.

Suggested Sources of Membership

Membership on the Public Advisory Committee can include representatives from: Government Agencies, Agriculture, Industry, Native People, Environmental

Groups, Chamber of Commerce, Conservation Authorities, Harbour Commissions, Labour, Citizens, Boating Clubs, Municipalities, Tourist Operators, Commercial Fishermen, Public Interest Groups, Public Health Units, Universities, Waterfront property owners, and/or Church Groups.

CHAIRMANSHIP:

A Chairman shall preside over Public Advisory Committee meetings. The criteria for selection of a Chairman must be premised on the individuals ability to oversee and direct the workings of a diverse grouping of interests in meeting the Committee objectives.

Appointment of the Chairman shall be made by the Committee as a whole. The Committee shall determine whether an alternate should be designated to serve in the absence of the Chairman.

RAP Team Coordinator shall be present at all Public Advisory Committee meetings, schedule permitting. A RAP team representative will attend Advisory Committee meetings in the absence of the Coordinator.

In order to ensure that all members of the Public Advisory Committee are kept fully informed of the process, all meetings of the Committee shall be preceded, in advance of any meeting, by an agenda and supporting reports.

SUB-COMMITTEES:

The Public Advisory Committee may appoint sub-committees to deal with individual issues being considered by the Public Advisory Committee.

PUBLIC ADVISORY COMMITTEE FACILITATOR:

The RAP team will provide the services of a facilitator to assist the Public Advisory Committee. Specific duties will include: organizing meeting dates and locations, preparing agendas and minutes, circulation of reports, and attending all Public Advisory Committee meetings as a non-voting member. The facilitator shall prepare an annual budget for the Public Advisory Committee for approval by the RAP Team.

SECTORS TO BE REPRESENTED

MUNICIPAL: municipalities involved are Murray Township, City of Trenton, City of Belleville, Sidney Township, Thurlow Township, Tyendinaga Township, Town of Deseronto, Richmond Township, Town of Napanee, Township of North Fredericksburgh, Township of South Fredericksburgh, Township of Adolphustown, North Marysburgh Township, Town of Picton, Sophiasburg Township, Ameliasburgh Township.

INDUSTRIAL: A variety, mainly concentrated in the west end of the Bay. (Trenton-Belleville)

ENVIRONMENTAL

GROUPS: Two groups only were identified in the area: Quinte Environmental Resources Association (QERA), and the Bay of Quinte Environmental Group. QERA is Belleville-Trenton based. Quinte Environmental Group is based in Prince Edward County.

OTHER SECTORS

HUMAN

HEALTH: There are 2 public health units, directly concerned with water quality in the Bay area. There are also numerous health care professionals and facilities involved in general health care.

FISHING: There are several fish and game clubs in the region, and large numbers of individuals who enjoy recreational fishing. Fishing derbies are an important aspect of many municipalities' tourism promotions activities.

COMMERCIAL: An industry that has undergone many changes over the years.

FISHING: Commercial fishing occurs at several locations throughout the bay.

TOURISM: A significant factor in the overall economy of the Bay of Quinte communities.

HABITAT PRESERVATION: Quinte Field Naturalists, Ducks Unlimited. Possibly others, not yet identified.

LABOUR: Belleville and District Labour Council.

AGRICULTURE: Three chapters of the Ontario Federation of Agriculture are in the area.

MOHAWKS OF THE BAY OF QUINTE, BOATING, OTHER RECREATION, SCIENTIFIC, ACADEMIC, CONSERVATION AUTHORITIES, PROPERTY OWNERS.

Appendix D. Mass loadings (BOD₅, total suspended solids and total phosphorus) to the Bay of Quinte from municipal sewage treatment plants (from Canviro 1987)

Source	Loading (kg/yr)		
	BOD ₅	TSS	TP
Trenton	51,500	45,300	700
Belleville	319,400	215,000	12,520
Picton	8,400	12,800	800
Deseronto	2,900	4,900	300
Prince Edward Heights*	600	600	70
CFB Trenton	10,500	11,600	910
Napanee	32,800	54,000	4,750
Total	426,100	344,200	20,050

* Estimated based on average flow of 150 m³/d.

Appendix E. Mass loadings (BOD₅, total suspended solids and total phosphorus to the Bay of Quinte from municipal water treatment plants (from Canviro 1987)).

Source	Contaminant	Stream Load (kg/y)		
		Microstrainer Backwash	Sedimentation Sludge	Filter Washwater
Trenton	BOD ₅	-	501	983
	TSS	-	21,077	9,396
	Total P	-	64	22
Belleville	BOD ₅	5,970	9,101	882
	TSS	33,582	532,510	41,287
	Total P	179	1,162	96
Picton	BOD ₅	-	313	1,978
	TSS	-	18,315	14,780
	Total P	-	40	42
Deseronto	BOD ₅	-	294	18
	TSS	-	17,200	271
	Total P	-	38	1
Napane	BOD ₅	-	498	910
	TSS	-	29,150	14,833
	Total P	-	64	18
Total	BOD ₅	5,970	10,707	4,771
	TSS	33,582	618,252	80,567
	Total P	179	1,368	179

Appendix F-1

Summary of bacteriological and inorganic and organic chemical analyses, Belleville Water Treatment Plant and distribution system (from Ontario Ministry of the Environment, 1987). A positive value denotes that the result is greater than the statistical limit of detection and is quantifiable; a '-' indicates that no sample was taken. No health related guidelines were exceeded.

Scan	Raw			Treated			Site 1			Site 2			Site 3		
	Tests	Positive	% Positive	Tests	Positive	% Positive	Tests	Positive	% Positive	Tests	Positive	% Positive	Tests	Positive	% Positive
Bacteriological	30	30	100	35	7	20	16	3	18	16	3	18	44	14	31
Chemistry (FLD)	26	26	100	54	54	100	34	34	100	42	42	100	88	88	100
Chemistry (LAB)	153	131	85	171	130	76	131	116	88	165	146	88	329	283	86
Metals	179	91	50	179	82	45	157	85	54	195	119	61	391	216	55
Chloroaromatics	78	0	0	104	0	0	52	2	3	65	0	0	130	1	0
Chlorophenols	6	0	0	6	0	0	-	-	-	-	-	-	-	-	-
PAH	68	0	0	68	0	0	-	-	-	-	-	-	-	-	-
Pesticides & PCB	157	0	0	201	0	0	97	0	0	125	0	0	248	0	0
Phenolics	9	1	11	9	0	0	-	-	-	-	-	-	-	-	-
Specific Pesticides	99	0	0	99	0	0	27	0	0	45	0	0	90	0	0
Volatiles	252	12	4	252	28	11	113	12	10	140	15	10	253	27	10
Total	1057	291		1178	301		627	252		793	325		1573	629	

Appendix F-2.

Summary of bacteriological and inorganic and organic chemical analyses, Deseronto Water Treatment Plant and distribution system (from Ontario Ministry of the Environment, 1987). A positive value denotes that the result is greater than the statistical limit of detection and is quantifiable; a '-' indicates that no sample was taken. No health related guidelines were exceeded.

Scan	Raw			Treated			Site 1		
	Tests	Positive	% Positive	Tests	Positive	% Positive	Tests	Positive	% Positive
Bacteriological	23	21	91	23	6	26	23	5	21
Chemistry (FLD)	18	18	100	36	36	100	53	53	100
Chemistry (LAB)	114	102	89	114	92	80	198	181	91
Metals	120	56	46	120	61	50	234	134	57
Chloroaromatics	78	0	0	78	0	0	78	0	0
Chlorophenols	6	0	0	6	0	0	-	-	-
PAH	102	0	0	102	0	0	-	-	-
Pesticides & PCB	150	0	0	148	0	0	148	0	0
Phenolics	5	0	0	5	1	20	-	-	-
Specific Pesticides	81	0	0	72	0	0	45	0	-
Volatiles	168	2	1	167	21	12	168	21	12
Total	865	199		871	217		947	394	

Appendix F-3.

Summary of bacteriological and inorganic and organic chemical analyses, Bayside School Water Treatment Plant (from Ontario Ministry of the Environment, 1987). A positive value denotes that the result is greater than the statistical limit of detection and is quantifiable; a '-' indicates that no sample was taken. Coliforms were detected in one treated water sample; no health related guidelines were exceeded.

Scan	Raw			Treated		
	Tests	Positive	% Positive	Tests	Positive	% Positive
Bacteriological	21	20	95	23	8	34
Chemistry (FLD)	13	13	100	34	34	100
Chemistry (LAB)	112	101	90	112	75	66
Metals	120	66	55	120	70	58
Chloroaromatics	78	0	0	78	0	0
Chlorophenols	18	1	5	18	0	0
PAH	102	1	0	102	2	1
Pesticides & PCB	150	0	0	150	0	0
Phenolics	6	1	16	6	0	0
Specific Pesticides	114	0	0	114	0	0
Volatiles	168	0	0	168	19	11
Total	902	203		925	208	

Appendix G. Annotated list of macroinvertebrates collected in the Bay of Quinte and adjacent Lake Ontario during the period 1966-84. Location abbreviations: LB, lower bay; MB, middle bay; UB, upper bay; BB, Big Bay Index Station; GL, Glenora Index Station; LO, Lake Ontario Index Station; W, widespread. Numerical abundance categories: abundant ($>1000/m^2$), very common ($500-999/m^2$), common ($100-499/m^2$), scarce ($<100/m^2$), and rare (occurring at one or two stations only at $<100/m^2$). Three time periods: prior to phosphorus removal (1966-68), following phosphorus reduction in detergents (1972-77), and after phosphorus reduction at waste-treatment plants (1982-84). All data are from Johnson and McNeil (1986).

	1966-68	1972-77	1982-84
Oligochaeta			
Lumbriculidae			
<u>Stylodrilus heringianus</u> Claparede	LO: common	LB: rare	LB: common
Naididae			
<u>Arcteonais lomondi</u> (Martin)	-	LB: common	-
<u>Chaetogaster diaphanus</u> (Gruithuisen)	-	LB: rare	-
<u>Nais pseudobtusa</u> Pigué	-	LB: rare	-
<u>N. variabilis</u> Pigué	-	LB: rare	-
<u>Nais</u> sp.	LO: rare	LB: rare	-
<u>Ophidonais serpentina</u> (Müller)	-	LB: rare	-
<u>Slavina appendiculata</u> (d'Udekem)	-	LB: rare	-
<u>Stylaria lacustris</u> (Linnaeus)	LB: rare	-	-
Tubificidae			
<u>Aulodrilus limnobius</u> Bretscher	LO: rare	LB: rare	-
<u>A. pigueti</u> Kowalewski	BB: v. common	BB + LB: common	-
<u>A. pluriseta</u> (Pigué)	LB + LO: v. common	BB + LB: common	GL: scarce
<u>Ilyodrilus templetoni</u> (Southern)	UB + LO: scarce	LB: rare	LB: rare
<u>Isochaetides freyi</u> (Brinkhurst)	LO: rare	-	-
<u>Limnodrilus cervix</u> Brinkhurst	UB: rare	-	-
<u>L. claparedeanus</u> Ratzel	LB: rare	LB: rare	LB: rare
<u>L. hoffmeisteri</u> Claparede	W: abundant	W: abundant	W: v. common
<u>L. profundicola</u> (Verrill)	-	BB: rare	BB: rare
<u>L. udekemianus</u> Claparede	LO: rare	LB: rare	-
<u>Potamothrix bavaricus</u> (Oschmann)	GL: abundant	LB: rare	-
<u>P. bedoti</u> (Pigué)	LO: scarce	LB: rare	-
<u>P. moldaviensis</u> Vejdovsky & Mrazek	LB + LO: common	LB: rare	LB: rare
<u>P. vejdoskvi</u> (Hrabe)	LB + LO: common	LB: v. common	LB: common
<u>Quistadrilus multisetosus</u> (Smith)	UB + MB: scarce	LB + LO: abundant	LB + LO: rare
<u>Spirosperma ferox</u> (Eisen)	LO: common	LB: rare	LB: v. common
<u>Tubifex tubifex</u> (Müller)	W: common	W: abundant	W: common
Hirudinoidea			
Glossiphonidae			
<u>Glossiphonia complanata</u> (Linnaeus)	LO: rare	-	-
<u>G. heteroclita</u> (Linnaeus)	LO: rare	-	-
<u>Helobdella stagnalis</u> (Linnaeus)	W: scarce	LB: rare	LB: rare

Appendix G. (continued).

	1966-68	1972-77	1982-84
Turbellaria			
Planariidae			
<u>Phagocata</u> spp.	LO: rare	-	-
Rhabdocoela			
<u>Hydrolimax</u> cf. <u>grisea</u> Haldeman	W: common	-	-
Gastropoda			
Sphaeriidae			
<u>Pisidium adamsi</u> Prime	LO: rare	-	-
<u>P. amnicum</u> (Muller)	LB: rare	LB: rare	-
<u>P. casertanum</u> (Poli)	W: common	LB + LO: v. common	LB + LO: common
<u>P. compressum</u> Prime	W: scarce	LB + LO: scarce	LB + LO: scarce
<u>P. conventus</u> Clessin	LO: abundant	LB + LO: common	LB + LO: scarce
<u>P. equilaterale</u> Prime	-	LB: rare	-
<u>P. ferrugineum</u> Prime	LO: rare	LB: rare	LB: rare
<u>P. henslowanum</u> (Sheppard)	W: common	LB + LO: scarce	LB + LO: scarce
<u>P. idahoense</u> Roper	LB + LO: scarce	LB + LO: scarce	LB: rare
<u>P. lilljeborgi</u> Clessin	W: common	LB + LO: common	LB + LO: scarce
<u>P. nitidum</u> Jenyns	LO: common	LB + LO: common	LB: scarce
<u>P. n.f. pauperculum</u> Jenyns	-	LB: rare	-
<u>P. punctatum</u> Sterki	LB: rare	LB: rare	LB: rare
<u>P. subtruncatum</u> Malm	W: scarce	LB: common	LB: common
<u>P. variable</u> Prime	LB: rare	LB: rare	LB: rare
<u>P. ventricosum</u> Prime	LB + LO: common	LB + LO: common	LB: scarce
<u>P. walkeri</u> Sterki	LB + LO: rare	-	-
<u>Sphaerium corneum</u> (Linnaeus)	LB + LO: common	LB + LO: scarce	-
<u>S. lacustre</u> (Muller)	MB + LO: rare	-	-
<u>S. nitidum</u> Clessin	LO: common	LB + LO: scarce	LB + LO: common
<u>S. partumeium</u> Say	GL: rare	LB: rare	-
<u>S. securis</u> (Prime)	-	LB: rare	-
<u>S. simile</u> (Say)	LB: rare	-	-
<u>S. striatinum</u> (Lamarck)	LB + LO: rare	LB: rare	LB + LO: rare
<u>S. transversum</u> (Say)	LO: rare	-	-
Unionidae			
<u>Anodonta grandis grandis</u> Say	W: common	-	-
<u>Elliptio complanata</u> (Lightfoot)	W: common	-	-
<u>Lampsilis radiata radiata</u> (Gmelin)	W: common	LB: rare	-
<u>L. r. siliquoidea</u> (Barnes)	W: common	-	-
<u>Leptodea fragilis</u> (Rafinesque)	BB: rare	-	-
<u>Proptera alata</u> (Say)	BB: rare	-	-
Bithyniidae			
<u>Bithynia tentaculata</u> (Linnaeus)	W: scarce	LB: scarce	LB: rare

Appendix G. (continued).

	1966-68	1972-77	1982-84
<u>Hydrobiidae</u>			
<u>Amnicola limosa</u> (Say)	LO: common	LB: scarce	LB: rare
<u>Probythinella lacustris</u> (Baker)	UB + MB: rare	-	-
<u>Lymnaeidae</u>			
<u>Fossaria obrussa</u> Say	LO: rare	LB: rare	-
<u>Lymnaea stagnalis jugularis</u> (Say)	-	LB: rare	-
<u>Pseudosuccinea columella</u> (Say)	-	LB: rare	-
<u>Stagnicola catascopium catascopium</u> (Say)	-	LB: rare	-
<u>Physidae</u>			
<u>Physella gyrina gyrina</u> Say	LO: rare	LB: rare	-
<u>Planorbidae</u>			
<u>Gyraulus deflectus</u> (Say)	LO: rare	-	-
<u>G. parvus</u> (Say)	LO: rare	LB: rare	-
<u>Helisoma anceps anceps</u> (Menke)	LB + LO: rare	-	-
<u>Promenetus exacuus</u> (Say)	LO: rare	-	-
<u>Pleuroceridae</u>			
<u>Goniobasis livescens</u> (Menke)	LO: rare	-	-
<u>Valvatidae</u>			
<u>Valvata piscinalis</u> (Muller)	MB + LB: rare	LB: rare	W: scarce
<u>V. sincera sincera</u> Say	LO: common	LB: scarce	W: scarce
<u>V. tricarinata</u> Say	W: common	LB: scarce	LB: rare
<u>Viviparidae</u>			
<u>Viviparus georgianus</u> (Lea)	-	LB: rare	-
<u>Crustacea</u>			
<u>Asellidae</u>			
<u>Caecidotea racovitzai racovitzai</u> (Williams)	LB + LO: abundant	LB + LO: common	LB + LO: common
<u>Lirceus lineatus</u> (Say)	LB + LO: common	LB: rare	-
<u>Mysidae</u>			
<u>Mysis relicta</u> (Loven)	LO: rare	-	LB: rare
<u>Gammaridae</u>			
<u>Gammarus fasciatus</u> Say	W: common	W: scarce	LB + LO: scarce
<u>Hyalellidae</u>			
<u>Hyalella azteca</u> (Saussure)	W: common	-	-

Appendix G. (continued).

	1966-68	1972-77	1982-84
Pontoporeiidae			
<u>Pontoporeia hoyi</u> Smith	LB + LO: abundant	LB + LO: abundant	LB + LO: abundant
Insecta/Diptera			
Chironomini			
<u>Chironomus anthracinus</u> group ^a	W: v. common	BB + LB: common	LB: common
<u>C. atritibia</u> (Malloch)	LB + LO: common	LB: common	LB: common
<u>C. plumosus</u> (Linnaeus)	W: common	BB + LB: scarce	BB + LB: scarce
<u>C. semi-reductus</u> group ^b	UB + MB: scarce	LB: rare	LB: rare
<u>Cladopelma</u> sp. ^c	UB + MB: common	LB: rare	BB + GL: rare
<u>Cryptochironomus digitatus</u> (Malloch) ^c	W: common	BB + LB: scarce	BB + LB: rare
<u>Dicrotendipes modestus</u> (Say) ^c	W: common	BB + LB: rare	LB: rare
<u>Einfeldia</u> sp.	-	LB: rare	-
<u>Endochironomus subtendens</u> (Townes) ^c	UB + LO: common	-	-
<u>Glyptotendipes</u> sp. ^d	UB: rare	-	-
<u>Harnischia</u> sp.	BB: common; GL: rare	LB: rare	-
<u>Microtendipes pedullus</u> (DeGeer)	MB + LO: scarce	BB + LB: rare	LB: rare
<u>Parachironomus abortivus</u> (Malloch) ^c	LO: scarce	LB: rare	-
<u>Paracladopelma</u> sp.	LO: rare	BB: rare	-
<u>Paralauterborniella</u> sp.	-	LB: rare	-
<u>Paratendipes albimanus</u> (Meigen)	UB: scarce	LB: rare	LB: rare
<u>Phaenopsectra</u> spp. ^e	UB: rare	LB: rare	LB: rare
<u>Polypedilum</u> spp. ^f	W: scarce	BB: LB: rare	LB: rare
<u>Pseudochironomus</u> sp.	MB: rare	-	LB: rare
<u>Stictochironomus</u> sp.	MB: rare	GL: rare	-
Tanytarsini			
<u>Cladotanytarsus</u> sp.	LO: rare	-	-
<u>Micropectra</u> nr. <u>dives</u> (Johannsen)	LB + LO: common	LB + LO: common	LB + LO: scarce
<u>Paratanytarsus</u> sp.	LO: rare	-	-
<u>Tanytarsus</u> sp. ^g	W: common	BB + LB: common	LB: scarce
Orthoclaadiinae			
<u>Cricotopus</u> sp.	LO: rare	-	-
<u>Diplocladius</u> sp.	BB: rare	-	-
<u>Heterotrissocladius</u> sp.	-	LO: rare	LB: rare
<u>Hydrobaenus</u> sp.	GL: rare	-	-
<u>Parametriochnemus</u> sp.	-	LB: rare	-
<u>Psectrocladius</u> spp. ^h	LO: rare	-	-
Tanypodinae			
<u>Ablabesmyia americana</u> Fittkau	LO: scarce	LB: rare	LB: rare
<u>Clinotanypus</u> cf. <u>punguis</u> (Loew)	LB + LO: rare	-	-
<u>Coelotanypus</u> sp.	UB: common	BB: scarce	BB: scarce
<u>Pentaneura</u> sp.	LO: rare	-	-

Appendix G. (continued).

	1966-68	1972-77	1982-84
<u>Procladius</u> spp. ⁱ	W: abundant	W: v. common	W: common
<u>Psectrotanypus</u> sp.	-	BB: rare	-
<u>Geratopogonidae</u>			
<u>Palpomyia</u> sp.	W: scarce	-	-
<u>Chaoboridae</u>			
<u>Chaoborus albatrus</u> Johnson	UB: scarce	BB: scarce	BB + GL: rare
Insecta/Trichoptera			
<u>Leptoceridae</u>			
<u>Ceraclea diluta</u> (Hagen)	LO: rare	-	-
<u>Leptocerus americanus</u> (Banks)	UB: rare	-	-
<u>Mystacides sepulchralis</u> (Walker)	MB + LB: rare	-	-
<u>Nectopsyche albida</u> (Walker)	LO: rare	-	-
<u>Oecetis</u> spp. ^j	LO: rare	-	LB: rare
<u>Triacnodes</u> sp.	LO: rare	-	-
<u>Lepidostomatidae</u>			
<u>Lepidostoma</u> sp.	LO: rare	-	-
<u>Polycentropidae</u>			
<u>Phylocentropus</u> sp.	LO: rare	-	-
<u>Polycentropus</u> sp.	UB: rare	-	-
Arachnida			
<u>Arrenuridae</u>			
<u>Arrenurus</u> sp.	MB: rare	-	-
<u>Hygrobatidae</u>			
<u>Hygrobates</u> sp.	LB: rare	-	-
<u>Lebertiidae</u>			
<u>Lebertia</u> sp.	MB: rare	-	-
<u>Limnesiidae</u>			
<u>Limnesia</u> sp.	UB + MB: scarce	-	-
<u>Pionidae</u>			
<u>Piona</u> sp.	W: scarce	-	-
<u>Unionicolidae</u>			
<u>Neumania</u> sp.	UB + MB: scarce	-	-
<u>Unionicola</u> sp.	W: scarce	-	-

Appendix G. (continued).

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- a - includes C. attenuatus Walker and C. anthracinus (Zetterstedt) (Johnson and Brinkhurst 1971a, appendix I).
 - b - includes C. sp. A and C. sp. B (Johnson and Brinkhurst 1971a, appendix I).
 - c - genus previously given as Chironomus (Johnson and Brinkhurst 1971a, appendix I).
 - d - includes G. sp. A and G. sp. B (Johnson and Brinkhurst 1971a, appendix I).
 - e - includes Tribelos jucundus (Walker)
 - f - includes P. cf. nebeculosum (Meigen) and P. cf. simulans Townes (Johnson and Brinkhurst 1971a, appendix I).
 - g - includes at least four species (Johnson and Brinkhurst 1971a, appendix I).
 - h - includes P. sp. A, P. sp. B and P. sp. C (Johnson and Brinkhurst 1971a, appendix I).
 - i - includes P. bellus (Loew), P. denticulatus Sublette, P. freemani Sublette, and P. subletti Roback.
 - j - includes O. sp. A (Johnson and Brinkhurst 1971a, appendix I).

Appendix H. List of plants found on transects in 1972-82 with common names, life forms, observed overwintering forms, observed seeds or spores, and previous records of occurrence in the Bay of Qunite. Life forms: S = submerged, F = floating leaved, E = emergent; overwintering forms: U = unchanged, R = rhizome, Ro = rosette, T = turion, WB = winterbud; reproduction: Se = seeds, Sp = spores; records: M = Macoun 1883-90, P = Palilioni (1977). All data are from Crowder and Bristow (1986).

Specific Name	Common Name	Life Forms	Overwintering Forms	Seeds or Spores	Records
<u>Chara braunii</u> Gm.	stonewort	S alga	U	Sp	
<u>C.globularis</u> Thuiu.	stonewort	S alga	U	Sp	
<u>Nitella flexilis</u> (L.) Ag.	stonewort	S alga	U	Sp	
<u>Drepanocladus</u> spp.	moss	S moss	U	-	
<u>Riccia fluitans</u> L.	liverwort	SF liverwort	U	-	
<u>Typha latifolia</u> L.	cattail	E	R	Se	M, P
<u>Najas flexilis</u> (Willd.) Rostk. & Schmidt	bushy pondweed	S	-	Se	M
<u>N. guadalupensis</u> (Spreng.) Magnus	bushy pondweed	S	-	Se	
<u>Potamogeton crispus</u> L.	pondweed	S	WB, R	Se	
<u>P. friesii</u> Rupr.	pondweed	S	WB	Se	
<u>P. pectinatus</u> L.	sago pondweed	S	T	Se	
<u>P. pusillus</u> L.	pondweed	S	WB	Se	
<u>P. perfoliatus</u> L. ssp. <u>richardsonii</u> (Benn.) Hult.	clasping leaf pondweed	S	R	Se	M
<u>P. zosterifolius</u> Schum. ssp. <u>zosteriformis</u> (Fern.) Hult.	flat stemmed pondweed	S	R, WB	Se	M
<u>Zannichella palustris</u> L.	horned pondweed	S	R	Se	M
<u>Alisma gramineum</u> Gmel.	water plantain	S, E	Ro, U	Se	
<u>Alisma plantago-aquatica</u> L.	water plantain	S, E	Ro	Se	P
<u>Sagittaria latifolia</u> Willd.	arrowhead	E	U, WB	Se	
<u>Elodea canadensis</u> Michx.	waterweed	S	U, WB	-	
<u>Vallisneria americana</u> Michx.	water celery	S	T, R	Se	M
<u>Hydrocharis morsus-ranae</u> L.	frogbit	F	T	Se	
<u>Calamagrostis canadensis</u> (Michx.) Nutt.	bluejoint	E	R	Se	
<u>Phalaris arundinacea</u> L.	reed canary grass	E	R	Se	
<u>Glyceria</u> spp.	manilla grass	E	R	Se	M, P
<u>Carex</u> spp.	sedge	E	R	Se	M, P
<u>Eleocharis acicularis</u> (L.) R. and S.	needle rush	S, E	R	Se	
<u>Lemna minor</u> L.	duckweed	F	T, U	-	
<u>L. trisulca</u> L.	star duckweed	S	U	-	
<u>Spirodela polyrhiza</u> (L.) Schleid.	big duckweed	F	T, U	-	
<u>Heteranthera dubia</u> (Jacq.) MacM.	mud plantain	S	R	Se	M
<u>Juncus</u> spp.	rush	E	R	-	M

Appendix H. (continued).

Specific Name	Common Name	Life Forms	Overwintering Forms	Seeds or Spores	Records
<u>Polygonum amphibium</u> L.	smartweed	F,E	R	Se	M
<u>Ceratophyllum demersum</u> L.	hornwort	S	T	Se	M
	coontail				
<u>Nuphar variegatum</u> Durand	yellow water lily	F	R	Se	
<u>Ranunculus aquatilis</u> L.	water crowfoot	S	U	Se	M
<u>Cardamine pensylvanica</u> Muhl.	bittercress	E	-	Se	M
<u>Callitriche hermaphrodita</u> L.	water starwort	S	U	Se	M
<u>Impatiens capensis</u> Meerb.	jewelweed	E	-	Se	
<u>Hypericum virginicum</u> L.	marsh St. John's wort	E	Ro	Se	
<u>Epilobium</u> sp.	willow herb	E	-	Se	
<u>Myriophyllum spicatum</u> L.	Eurasian milfoil	S	U	Se	
<u>M. exallescens</u> Fern.	milfoil	S	T	Se	(M?)
<u>Sium suave</u> Walt.	water parsnip	E	-	Se	
<u>Asclepias exaltata</u>	milkweed	E	R	Se	
<u>Cuscuta gronovii</u> Willd.	dodder	E	-	Se	
<u>Lycopus americanus</u> Muhl.	water horehound	E	R	Se	
<u>Scutellaria epilobiifolia</u> Hamilton	skullcap	E	R	-	
<u>Utricularia intermedia</u> Hayne	bladderwort	S	T	Se	M
<u>U. minor</u> L.	bladderwort	S	T	-	
<u>Galium triflorum</u>	bedstraw	E	R	Se	
<u>Campanula aparinoides</u>	marsh bluebell	E	?	Se	
<u>Solidago</u> sp.	goldenrod	E	R	-	

Appendix I. Fish species found in the Bay of Quinte from Hurley (1986). Those species followed by D were recorded by Dymond et al. (1929) in 1928, but not in recent collections.

Petromyzonidae - lampreys	
<u>Petromyzon marinus</u> Linnaeus	sea lamprey
Acipenseridae - sturgeons	
<u>Acipenser fulvescens</u> Rafinesque	lake sturgeon
Lepisosteidae - gars	
<u>Lepisosteus osseus</u> (Linnaeus)	longnose gar
Amiidae - bowfins	
<u>Amia calva</u> Linnaeus	bowfin
Clupeidae - herrings	
<u>Alosa pseudoharengus</u> (Wilson)	alewife
<u>Dorosoma cepedianum</u> (Lesueur)	gizzard shad
Salmonidae - whitefishes, ciscoes, salmon, and trout	
<u>Oncorhynchus kistutch</u> (Walbaum)	coho salmon
<u>O. tshawytscha</u> (Walbaum)	chinook salmon
<u>Salmo gairdneri</u> Richardson	rainbow trout
<u>S. trutta</u> Linnaeus	brown trout
<u>Salvelinus namaycush</u> (Walbaum)	lake trout
<u>S. fontinalis</u> (Mitchill) X	
<u>S. namaycush</u> (Walbaum)	splake
<u>Coregonus artedii</u> Lesueur	cisco, lake herring
<u>C. clupeaformis</u> (Mitchill)	lake whitefish
<u>Prosopium cylindracum</u> (Pallas)	round whitefish (D)
Osmeridae - smelts	
<u>Osmerus mordax</u> (Mitchill)	rainbow smelt
Hiodontidae - mooneyes	
<u>Hiodon tergisus</u> Lesueur	mooneye
Umbridae - mudminnows	
<u>Umbra limi</u> (Kirtland)	central mudminnow (D)
Esocidae - pikes	
<u>Esox americanus vemiculatus</u> Lesueur	grass pickerel
<u>E. lucius</u> Linnaeus	northern pike
<u>E. masquinongy</u> Mitchill	muskellunge
Cyprinidae - minnows and carps	
<u>Carassius auratus</u> (Linnaeus)	goldfish
<u>Cyprinus carpio</u> Linnaeus	carp
<u>Notemigonus crysoleucas</u> (Mitchill)	golden shiner
<u>Notropis atherinoides</u> Rafinesque	emerald shiner
<u>N. chrysocephalus</u> (Rafinesque)	striped shiner
<u>N. hudsonius</u> (Clinton)	spottail shiner

Appendix I. (continued).

<u>N. spilopterus</u> (Cope)	spotfin shiner
<u>N. heterodon</u> (Cope)	blackchin shiner
<u>N. cornutus</u> (Mitchill)	common shiner
<u>N. bifrenatus</u> (Cope)	bridle shiner (D)
<u>N. stramineus</u> (Cope)	sand shiner
<u>Pimephales promelas</u> Rafinesque	fathead minnow
<u>P. notatus</u> (Rafinesque)	bluntnose minnow
<u>Semotilus corporalis</u> (Mitchill)	fallfish
<u>Rhinichthys cataractae</u> (Valenciennes)	longnose dace
Catostomidae - suckers	
<u>Carpiodes cyprinus</u> (Lesueur)	quillback
<u>Catostomus commersoni</u> (Lacepede)	white sucker
<u>Hypentelium nigricans</u> (Lesueur)	northern hog sucker
<u>Ictalobus cyprinellus</u> (Valenciennes)	bigmouth buffalo
<u>Moxostoma anisurum</u> (Rafinesque)	siver redhorse
<u>M. macrolepidotum</u> (Lesueur)	shorthead redhorse
<u>M. valenciennesi</u> Jordon	greater redhorse
Ictaluridae - bullheads and catfishes	
<u>Ictalurus nebulosus</u> (Lesueur)	brown bullhead
<u>I. punctatus</u> (Rafinesque)	channel catfish
<u>Noturus flavus</u> Rafinesque	stonecat
<u>N. gyrinus</u> (Mitchill)	tadpole madtom (D)
Anguillidae - freshwater eels	
<u>Anguilla rostrata</u> (Lesueur)	American eel
Cyprinodontidae - killifishes	
<u>Fundulus diaphanus</u> (Lesueur)	banded killifish
Gadidae - cods	
<u>Lota lota</u> (Linnaeus)	burbot
Atherinidae - silversides	
<u>Labidesthes sicculus</u> (Cope)	brook silverside
Gasterosteidae - sticklebacks	
<u>Gasterosteus aculeatus</u> Linnaeus	threespine stickleback
<u>Culaea inconstans</u> (Kirtland)	brook stickleback
<u>Pungitius pungitius</u> (Linnaeus)	ninespine stickleback
Percospidae - trout-perches	
<u>Percopsis omiscomaycus</u> (Walbaum)	trout-perch
Percichthyidae - temperate basses	
<u>Morone americana</u> (Gmelin)	white perch
<u>M. chrysops</u> (Rafinesque)	white bass

Appendix I.(continued).

Centrarchidae - sunfishes

<u>Ambloplites rupestris</u> (Rafinesque)	rock bass
<u>Lepomis gibbosus</u> (Linnaeus)	pumpkinseed
<u>L. macrochirus</u> Rafinesque	bluegill
<u>Micropterus dolomieu</u> Lacepede	smallmouth bass
<u>M. salmoides</u> (Lacepede)	largemouth bass
<u>Pomoxis nigromaculatus</u> (Lesueur)	black crappie

Percidae - perches

<u>Etheostoma nigrum</u> Rafinesque	johnny darter
<u>E. flabellare</u> Rafinesque	fantail darter
<u>Perca flavescens</u> (Mitchill)	yellow perch
<u>Percina caprodes</u> (Rafinesque)	logperch
<u>Stizostedion vitreum vitreum</u> (Mitchill)	walleye
<u>S. vitreum glaucum</u> Hubbs	blue pike (now extinct in Lake Ontario)
<u>S. canadense</u> (Smith)	sauger (D)

Sciaenidae - drums or croakers

<u>Aplodinotus grunniens</u> Rafinesque	freshwater drum
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Cottidae - sculpins

<u>Cottus bairdi</u> Girard	mottled sculpin
<u>C. cognatus</u> Richardson	slimy sculpin

Appendix J. Consumption guidelines for sports fish in the Bay of Quinte.

		Fish size in centimetres (inches) Longueur du poisson en centimètres (pouces)											
Waterbody/ Cours d'eau	Fish Species/ Espèces de poisson	< 15 < (5)	15-20 (6-8)	20-25 (8-10)	25-30 (10-12)	30-35 (12-14)	35-45 (14-18)	45-55 (18-22)	55-65 (22-26)	65-75 (26-30)	> 75 > (30)		
Lake Ontario #4 Lac Ontario N° 4 Bay of Quinte/Baie de Quinte General/Général 4409/7723 Hastings & Prince Edward Cos. Cités d'Hastings et de Prince Edward	Walleye ² Doré ²												
	Northern Pike ² Brochet ²												
	Largemouth Bass ² Achigan à grande bouche ²												
	Brown Bullhead ² Barbotte brune ²												
	American Eel ² Anguille d'Amérique ²												
	Channel Catfish ² Barbue de rivière ²												
	White Bass ⁵ Bar blanc ⁵												
	Smallmouth Bass ⁶ Achigan à petite bouche ⁶												
Lake Ontario #4 Lac Ontario N° 4 Bay of Quinte/Baie de Quinte Trent River mouth Embouchure de la rivière Trent 4406/7734 Sydney Twp./Canton de Sidney Hastings Co./Cité d'Hastings	Walleye ^{5, 6} Doré ^{5, 6}												
Lake Ontario #4 Lac Ontario N° 4 Bay of Quinte/Baie de Quinte Trenton to Belleville Trenton à Belleville 4410/7725 Hastings & Prince Edward Cos. Cités d'Hastings et de Prince Edward	Walleye ² Doré ²												
	Yellow Perch ¹ Perchaude ¹												
Lake Ontario #4 Lac Ontario N° 4 Bay of Quinte/Baie de Quinte Belleville, Telegraph Narrows, Long Reach Belleville, Détroit Telegraph, Tronçon Long 4410/7705 Hastings & Prince Edward Cos. Cités d'Hastings et de Prince Edward	Walleye ² Doré ²												
	Largemouth Bass ² Achigan à grande bouche ²												
	Carp ² Carpe ²												
Lake Ontario #4 Lac Ontario N° 4 Bay of Quinte/Baie de Quinte Hay Bay/Baie Hay 4410/7656 Lennox & Addington Co. Cité de Lennox et d'Addington	White Perch ^{2, 7} Bar-perche ^{2, 7}												
	Yellow Perch ^{2, 7} Perchaude ^{2, 7}												
	Gizzard Shad ² Alose à gésier ²												
	Walleye ² Doré ²												
	Northern Pike ² Brochet ²												
Lake Ontario #4 Lac Ontario N° 4 Keith Shoal, Adolphus Reach Baie Keith, Tronçon Adolphus 4402/7659 N. Marysburgh Twp. Canton de N. Marysburgh Prince Edward Co./Cité de Prince Edward	Walleye ^{5, 6} Doré ^{5, 6}												
Lake Ontario #4 Lac Ontario N° 4 Picton Bay/Baie Picton 4402/7707 Prince Edward Co. Cité de Prince Edward	Rainbow Smelt ¹ Éperlan arc-en-ciel ¹												
Lake Ontario #4 Lac Ontario N° 4 Bay of Quinte, Glenora to Upper Gap Baie de Quinte, Glenora à Upper Gap 4403/7657 N. Marysburgh Twp. Canton de N. Marysburgh Prince Edward Co./Cité de Prince Edward	American Eel ² Anguille d'Amérique ²												
	Whitefish ² Grande corégone ²												

Consumption Guidelines

					
One week	No restrictions	10 meals per wk. 2.3 kg./wk. (5.1 lb./wk.)	7 meals per wk. 1.54 kg./wk. (3.4 lb./wk.)	1 or 2 meals/wk. 0.45 kg./wk. (1 lb./wk.)	None
Two weeks	No restrictions	5 meals per wk. 1.3 kg./wk. (2.8 lb./wk.)	4 meals per wk. 0.86 kg./wk. (1.9 lb./wk.)	1 or 2 meals/wk. 0.45 kg./wk. (1 lb./wk.)	None
Three weeks	No restrictions	4 meals per wk. 0.95 kg./wk. (2.1 lb./wk.)	3 meals per wk. 0.63 kg./wk. (1.4 lb./wk.)	1 or 2 meals/wk. 0.45 kg./wk. (1 lb./wk.)	None
Long-term consumption	No restrictions	0.226 kg./wk. (0.5 lb./wk.)	0.136 kg./wk. (0.3 lb./wk.)	1 or 2 meals per month 0.45 kg./mo. (1 lb./mo.)	None

Contaminant identification

1	Mercury
2	Mercury, PCB, mirex and pesticides
3	PCB, mirex and pesticides
4	Mercury, PCB and mirex
5	Mercury, other metals, PCB, mirex and pesticides
6	Mercury, other metals
7	2,3,7,8-TCDD (Dioxin)
8	Toxaphene

Identification des polluants

Mercure
Mercure, BPC, mirex et pesticides
BPC, mirex et pesticides
Mercure, BPC et mirex
Mercure, autres métaux, BPC, mirex et pesticides
Mercure et autres métaux
2,3,7,8-TCDD (dioxine)
Toxaphène

Children under 15 and women of child-bearing age should eat only .

Les enfants de moins de 15 ans et les femmes en âge de procréer ne devraient manger que des poissons représentés par .

APPENDIX K. Technical reports and supporting documentation completed or in preparation as part of the Bay of Quinte Remedial Action Plan

Bay of Quinte Remedial Action Plan: Progress Report
(February 1987)

Technical Report No. 1 Bay of Quinte Remedial Action Plan:
An Evaluation of Persistent Toxic Contaminants in the Bay of Quinte Ecosystem January 1988.

Technical Report No. 2 Bay of Quinte Remedial Action Plan:
An Evaluation of Point Source Discharges to the Bay of Quinte Ecosystem March 1988.

Technical Report No. 3 Bay of Quinte Remedial Action Plan:
The Feasibility of Increasing the Hydrologic Flushing Rate of the Upper Bay of Quinte November 1987.

Technical Report No. 4 Bay of Quinte Remedial Action Plan:
Analysis of Agricultural Diffuse Source Loadings to the Bay of Quinte September 1988.

Technical Report No. 5 Bay of Quinte Remedial Action Plan:
1987 Bacteriological Water Quality at Trenton, Deseronto and Picton - Bay of Quinte January 1989.

Technical Report No. 6 Bay of Quinte Remedial Action Plan:
An Ecosystem Based Analysis of Remedial Options November 1988.

Technical Report No. 7 Bay of Quinte Remedial Action Plan:
Feasibility of Decreasing the Internal Phosphorus Loadings in the Upper Bay of Quinte June 1989.

Technical Report No. 8 Bay of Quinte Remedial Action Plan:

Technical Feasibility of Landfills as Potential Sources of Persistent
Toxic Contaminants in the Bay of Quinte December 1989.

Technical Report No. 9 Bay of Quinte Remedial Action Plan:

Distribution, Species Composition and Biomass of Macrophytes in the Bay
of Quinte - A Comparison of Methodologies December 1989.

Technical Report No. 10 Bay of Quinte Remedial Action Plan:

Report on the Feasibility of Re-establishing Aquatic Macrophytes in the
Bay of Quinte In preparation.

Socio-Economic Profile for the Bay of Quinte RAP Evaluation Study In
preparation.

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